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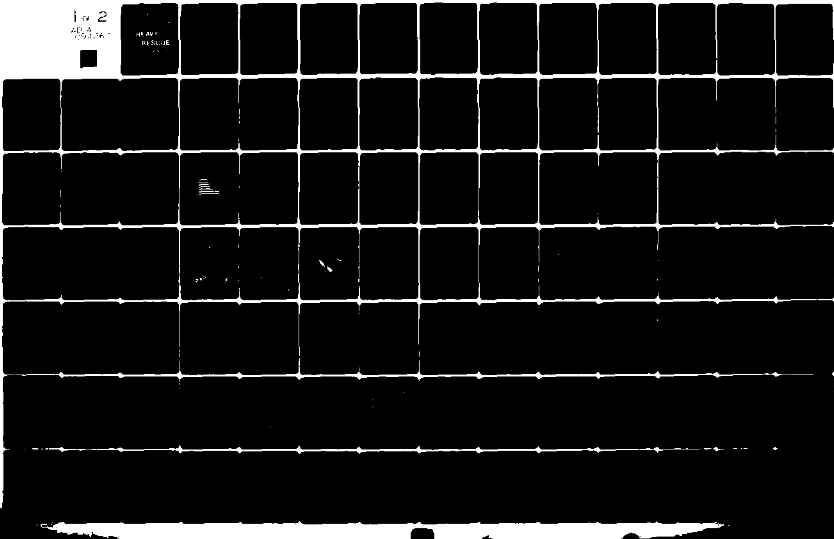

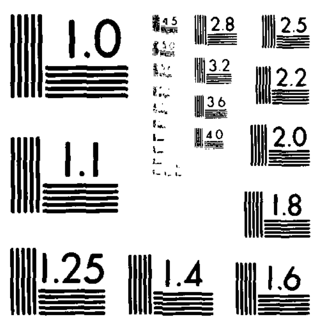

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HEAVY RESCUE

STUDENT MANUAL

for

FEDERAL EMERGENCY MANAGEMENT AGENCY
WASHINGTON, D.C.

NOVEMBER 1980

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HEAVY RESCUE - STUDENT MANUAL

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Fire Service Training and Education Program
Edward W. Bent, Supervisor
Office of the State Fire Marshal

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for

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This report has been reviewed in the Federal Emergency Management Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Federal Emergency Management Agency.

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FOREWORD

Innovation and progress in the development of rescue devices and techniques makes possible significant improvement in the capability for heavy rescue. Effective utilization of the new equipment, tools and techniques requires the mastering of skills in addition to those formerly associated with heavy rescue operations. This manual is intended to provide a continuum in the development of rescue skills for those who have completed basic rescue and vehicular extrication training or have gained practical experience sufficing for such training.

The manual was developed as a revision to the United States Department of Defense Manual, HEAVY DUTY RESCUE, No. IG 14-3.

Funding of the project was provided, through grant, by the Federal Emergency Management Agency, Washington, D.C.

October 1980

HEAVY RESCUE STUDENT MANUAL

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INTRODUCTION

In addition to the possibility of war-caused emergencies, the diversity in climatic, geologic and topographic features continually subject the country to the full spectrum of natural destructive forces. A dynamic society presents all the modern-day hazards of agriculture, commerce, habitat, industry, and transportation. Individually or in combination, these characteristics constitute an omnipresent and often realized threat of disaster.

This manual has been developed to assist rescue personnel during major rescue operations. It provides the essentials for both large and small communities to function effectively in the rescue field. Personnel equipped and trained for this function can increase human resources for recovery of survivors and saving the lives of many who might otherwise perish.

Heavy rescue operations, like other emergency services, may be required in the next few minutes, or may not be needed for long periods of time.

Rescue training is most effective when conducted under realistic conditions. Excellent training facilities can be improvised in any community where abandoned or condemned buildings are available. Such buildings can be readily adapted for rescue training, including self-extrication from shelter techniques.

Under emergency conditions, rescue squads may be ordered to unfamiliar areas and work with rescue units with which they have had no previous contact. Effective, cooperative operations will depend in large measure on similarity of procedures, techniques, training and equipment.

Use of tools, equipment and materials should not be limited by the scope of application presented in this manual. Consideration must be given for the use of equipment, materials and tools in substitution of those utilized for specific application in this manual. Materials, tools and other resources found at the incident scene can often be employed to achieve the goal of rescuers.

P A R T O N E

ORGANIZATION

There are three basic elements necessary for an effective physical rescue: Organization, Procedures, and Resources.

There are many different types of rescue teams formed throughout the United States. During any major disaster these teams may be mobilized into action. It is of utmost importance that these teams are organized. In every disaster, a period of time elapses before a meaningful organization of rescuers is accomplished. The longer it takes to get organized, the more the rescuers and victims are subjected to the possibility of further injury or total neglect. This overall organization is a community problem and must be overcome through community disaster planning.

The organization chart on the following page represents an Incident Command System which reflects the combination of facilities, resources, procedures, and communications operating within a common organizational structure. This organization provides effective management of assigned resources to accomplish stated objectives pertaining to life safety and rescue of trapped persons.

Due to the period of confusion which exists immediately after any disasterous event, the individual rescue teams must have organization. Following is a guideline for rescue team organization:

Heavy Rescue Team

1. Trained and equipped for operations in heavy rescue, and consists of:

   - Team leader
   - 4-6 team members

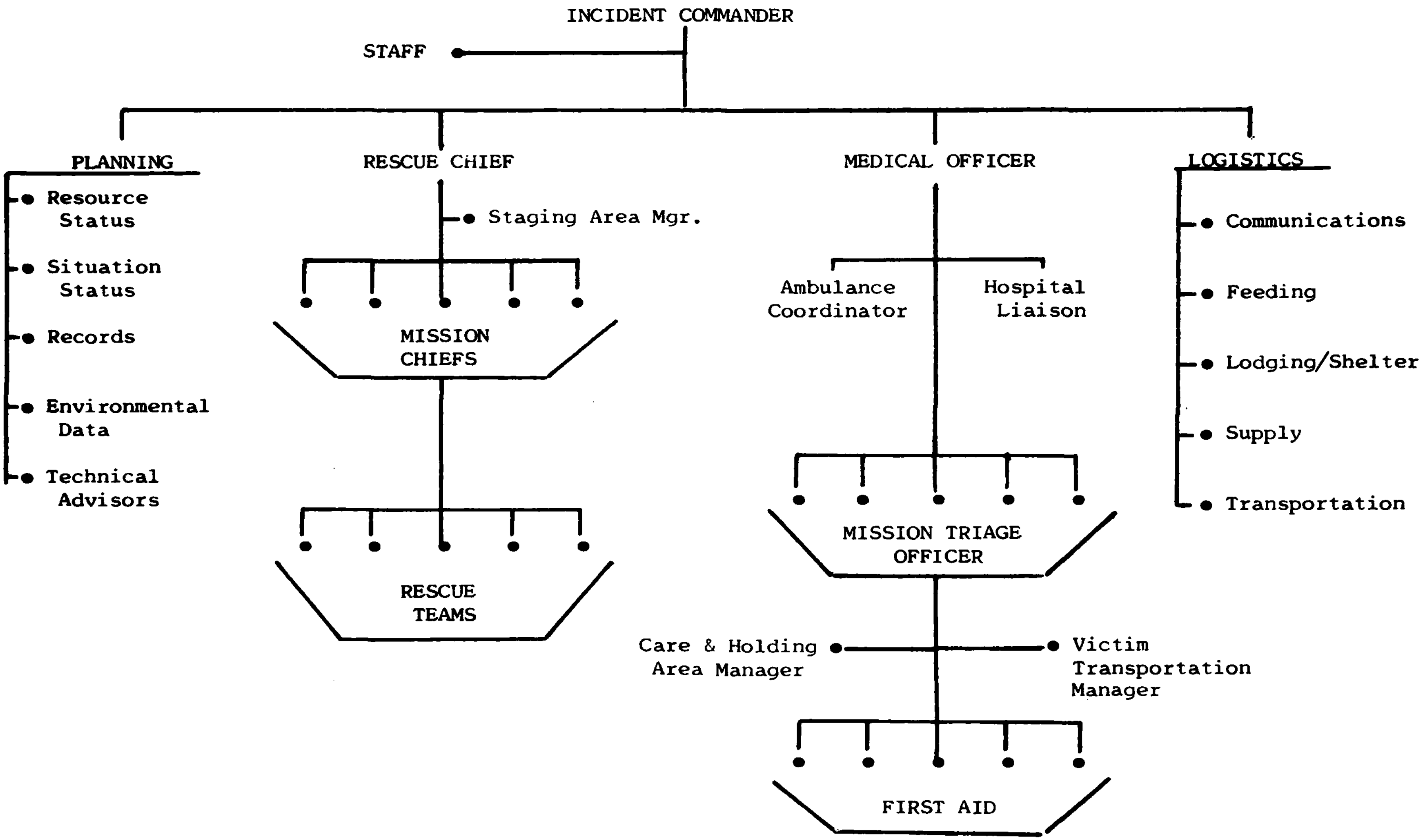
   A. Team Leader is responsible for operation of the rescue team. In preparation for emergency, he should:

   - Organize the team.
   - Supervise training.
   - Develop and enforce regulations for team operation.
   - Supervise obtaining, replacing, and maintaining equipment.
   - Conduct reconnaissance and inspection, locating and identifying and special hazrrds in the area.
   - Direct the team during exercises.

   During an emergency, the Team Leader should:

   - Report to incident as directed.
   - Conduct reconnaissance.
   - Make assignments to team leaders at the scene of operations.
   - Arrange for spot training of expanded rescue forces (including training during the in-shelter period) as appropriate.

ORGANIZATION FOR LARGE-SCALE RESCUE OPERATIONS



- Ensure correct rescue methods and techniques are used.
- Request additional men, tools and assistance as needed.
- Arrange for relief periods of teams.
- Make reports, as required, following completion or suspension of each operation.

COMMUNICATIONS

Communications is a vital element in any rescue operation. We must be able to communicate with victims, one another, and other agencies. Sometimes this can be done face to face. At other times we must rely on means such as telephone, radio, bullhorn, hand signals, rope signals or written messages.

Whichever method or combination of methods is utilized, there should be a means of establishing priorities, routing, and a backup system in case of failure to any part. First priortiy should be establishment of an overall communication plan, with the following order of priorities:

- Communications to report size-up and conditions.
- Communications to locate victims for coordination of rescue.
- Communications to establish victim/rescue rapport.
- Special problem communications.

Most emergency service agencies have radio systems with one or more frequencies to provide mobile units with radio communication capability. Many emergency service agencies have mobile communication vans, trailers or trucks which can be used at the scene of an incident to supplement fixed base communication centers. Arrangements must be made to provide auxiliary power to communication centers in case of power failure.

All emergency service agencies utilize public telephone service and have some type of backup system (usually radio) in the event of system failure. Some agencies have fire department telephone lines, teletype or other means to provide written communication.

Hard wire or sound powered units are used where radio is not effective or reliable such as with high rise or subsurface incidents. Many high rise, subsurface and other occupancies have their own communication systems which may be utilized during emergency incidents. These may consist of telephone, hard copy or radio systems.

Public utilities, transportation, construction and other agencies may have communication capabilities which could be utilized during emergency operations. Effective communications are required for successful completion of any large-scale rescue. However, effective communications (either inter or intra-agency) seldom occur. Some problems encountered are:

- Frequency overload.
- Different frequencies used by different agencies.
- Natural/manmade barriers.
- Radio terminology.
- Radio use discipline.

Other agencies may be able to provide additional or backup systems during emergencies at local, county, state and federal level.

SPECIAL RESCUE PROBLEMS

The success of each type rescue identified in this manual is predicated on being able to reach the scene expediently and safely. It is of paramount importance to preplan for potential access problems. During a major calamity of widespread nature such as earthquake or flood, the once smooth and obvious routes will have vanished. The road becomes debris and utility-covered, cracked and disrupted, and congested by fire fighters and confused citizens. Some access problems are generally very obvious such as bridges and overpasses being out, power poles and building materials on the roadways, flooding, snow drifts, unbridgeable cracks, etc. These may be so obvious as to be forgotten. Some access problems are not quite so obvious; i.e.,curiosity seekers congesting roadways, broken underground water pipes undermining roads, trains blocking crossings, electrically-energized areas, poor visibility due to dust or fog, deep muddy areas, etc.

DAMAGE TO BUILDINGS

The construction of a building gives some indication of how it may collapse as a result of fire, explosion or natural disaster such as earthquake. Almost all types of damaged structures will contain voids or spaces in which trapped persons may remain alive for comparatively long periods. To know where the safe places may be, it is necessary to know the characteristics of various types of building construction.

Building codes categorize structures by fire potential such as wood, frame, ordinary or masonry, heavy timber and non-combustible construction. Although fire is one of the considerations for rescue teams, the collapse of a building depends upon the method of construction, materials used, and the force or reason for the collapse.

The two main types of building construction are framed structures and wall bearing structures. A framed building is one with a "skeleton" system of beams and columns which make up the frame, or load bearing portion of the building. The floors, interior partitions and roof are supported by beams and transmit their weight to the foundation through the columns. Wall bearing buildings are those in which the foundations and walls support the weight of the floors, interior partitions and roof. Non-structural elements are not as stable as comparable structural or load bearing elements.

The wooden frame walled buildings (usually referred to as "frame buildings") are actually wall bearing buildings, as the weight of the floors, partitions and roof are supported by the walls and the foundation under them.

Safety factors built into buildings are rarely adequate to assure there will not be successive collapse in the wake of a first collapse. Aftershocks in an earthquake, added weight to a damaged building from water used for firefighting, or even the movement of rescue personnel working in a damaged building, can cause further collapse. Failure of one part of a steel frame building will often place stress on other parts of the building, thus extending the area of damage or collapse.

One of the structural elements of today's modern building is the truss. Trusses perform the same function as a beam. Trusses can provide, huge, clear spans at a weight considerably less than would be required of a beam. Truss rigidity rests in the geometrical principle that only one triangle can be formed from any three lines. Failure of any element of the truss can cause failure of the entire truss. If one truss fails, then it is very likely that others will also fail, causing the collapse of the entire roof or floor.

The larger, multistoried framed buildings have steel columns, beams, floor joists, and roof beams or trusses, which support the weight of the walls, partitions, roof, and exterior covering. These buildings use a combination of wood, steel and concrete in their construction.

Large, wall bearing buildings are usually built with masonry or concrete walls with wood or steel floor joists and roof rafters. Trusses are also used in place of roof rafters in this type of construction. If the roof collapses in wall bearing buildings, especially masonry, the top three or four feet of wall is pulled inward. Below this point, the rest of the wall would probably fall outward, causing the release of the floor joists on multi-storied buildings, resulting in the interior collapse of floors.

Frames structures generally withstand damage better than unframed buildings because of a tendency for the force on the building to be distributed through the framing. Wall panels may be destroyed without demoloshing the frame, and the floors may remain intact or only partially collapse. Debris and rubble will result from the force, but not of the quantity and nature likely to result from collapse of a wall bearing building.

Reinforcing steel and fire-distorted structural steel frames may create difficult and hazardous rescue problems. However, these materials will create many safe places from which victims may be rescued. Rescue from framed structures may not be as difficult as from unframed buildings. However, these buildings are usually large and multi-storied and contain many occupants. Rescue of more people and from greater heights may present additional problems. When bearing

walls are destroyed or damaged, the floors are likely to collapse completely or become extremely dangerous. If bearing walls are damaged near their foundation, remaining upper parts are likely to be rendered unsafe. The large amounts of debris and rubble generally resulting from damaged masonry buildings cause rescue operations to be complicated and time consuming, as well as dangerous.

HIGH RISE

Is strategy any different for a high-rise incident than perhaps for a large single-story structure? The answer is YES, and the basic reasons for this difference are the ground rules which a high-rise incident impose upon field commanders. Some of these ground rules are:

- Operating distance from the structure.
- Conveyance systems within the building.
- An all-glass, exterior-sealed window.
- Time restrictions.

This list could go on and one, but you get an idea from the above examples. Many normal operational procedures simply will not work in high-rise incidents, or the time required to implement them makes them impractical.

High-rise structures have certain characteristics which must be understood if strategy is to be sound and overall objective of rescue obtained.

What constitutes a high-rise building:

- Over 75 feet in height.
- Designed for human occupancy.

There are certain building design features which would have a direct effect on strategy and ability to complete a major rescue operation by using the following built-in features of the building:

- Communication systems.
- Fire Department communications systems.
- Emergency elevator control system.
- Emergency power system.
- Enclosed stair shaft ventilation system.
- Fire control station system.
- Emergency helicopter landing facility.

Another feature is steel framework, center core design, with light-weight or moveable interior walls. Most buildings have at least four stairwells and different height elevator banks.

High-rise structures may contain several thousand persons and evacuation and/or extrication of these people is impossible. The twin ARCO towers (52 stories each) in Los Angeles, probably contain the largest number of people in a single complex in the state (about 10,000).

During a disaster (major fire, earthquake, aircraft crash, etc.), injuries to occupants can be expected from fire, falling objects, and certainly from falling glass. Rescue operations from such buildings may tax to the limit resources of not only local authorities, but those of mutual aid.

The following operational strategy is mandatory when considering rescue of occupants from a high-rise building:

- Priority of who will be rescued (medical triage).
- Safe place of refuge within the building versus evacuation.
- Bringing casualties down versus up for helicopter transport.
- Resources necessary to accomplish rescue.
- Time to accomplish rescue.
- What will be "saved" versus resources expended.

Persons or agencies who have valuable knowledge about the building and can assist in your strategy/tactics development are:

- Building management, maintenance, and engineering staff.
- Elevator companies.
- Local Water and Power authorities.
- Private contractors with high-rise lifting equipment (cranes, construction elevators, etc.).
- Military, local government, or private contractors with helicopter capabilities.

It is anticipated that high-rise structures will withstand total collapse, and the basic structure will be intact except for the exterior facing. Utilities will probably be out; however, such structures have built-in emergency generators to provide power to selected appliances.

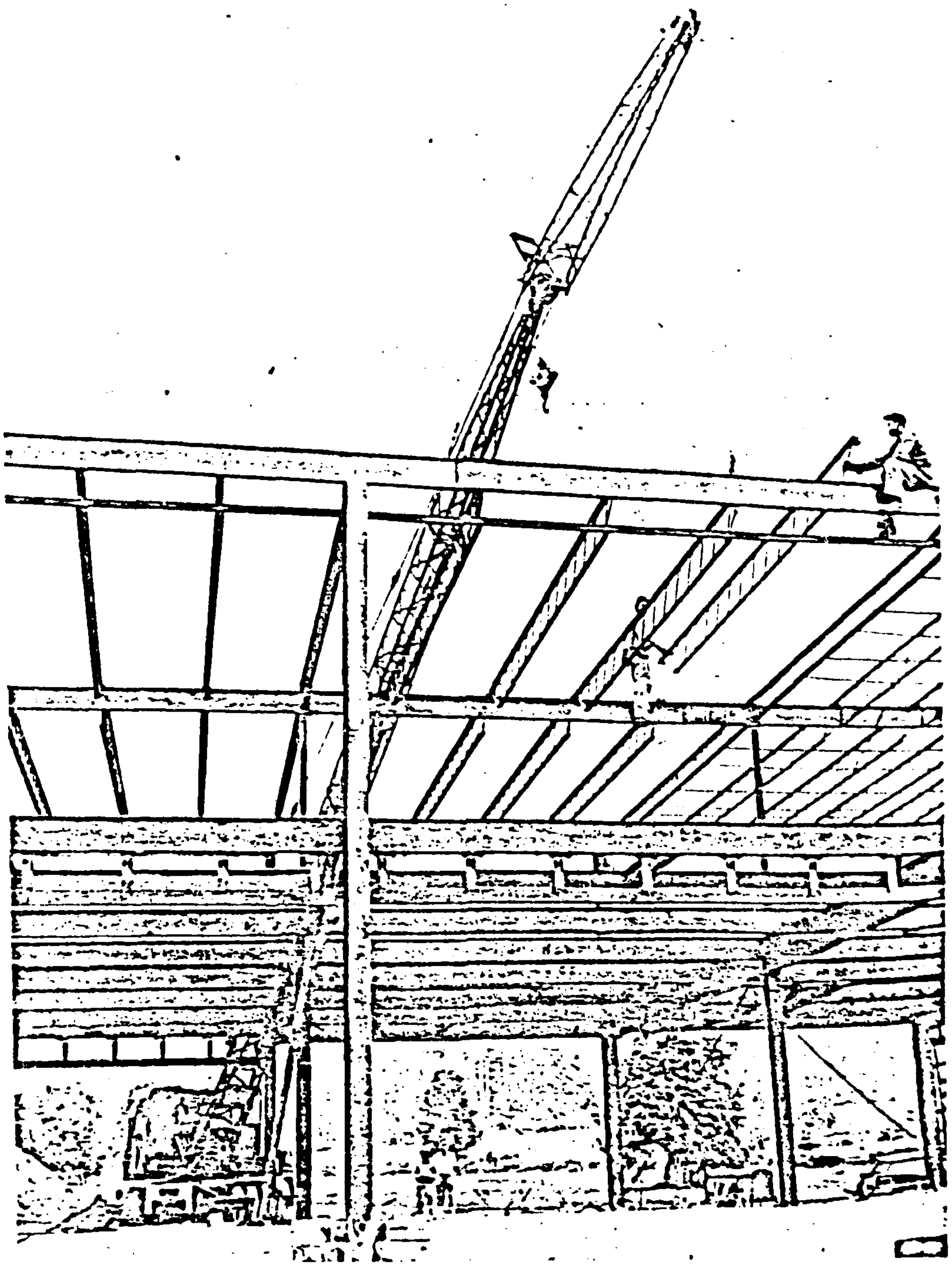
The decision to rescue, and how, will be based on observed and informed facts. It is impractical to evacuate hundreds of casualties from a high-rise building one at a time. It is imperative a plan and command structure be established.

Consideration should be given to evacuation from upper floors by helicopter; from the roof or from windows by rescue nets, harnesses, or by a suspended maneuvering system-type vehicle. Casualties may be transported either up or down via elevator if they are operational. This is surely the fastest method and requires the fewest rescuers for transporting.

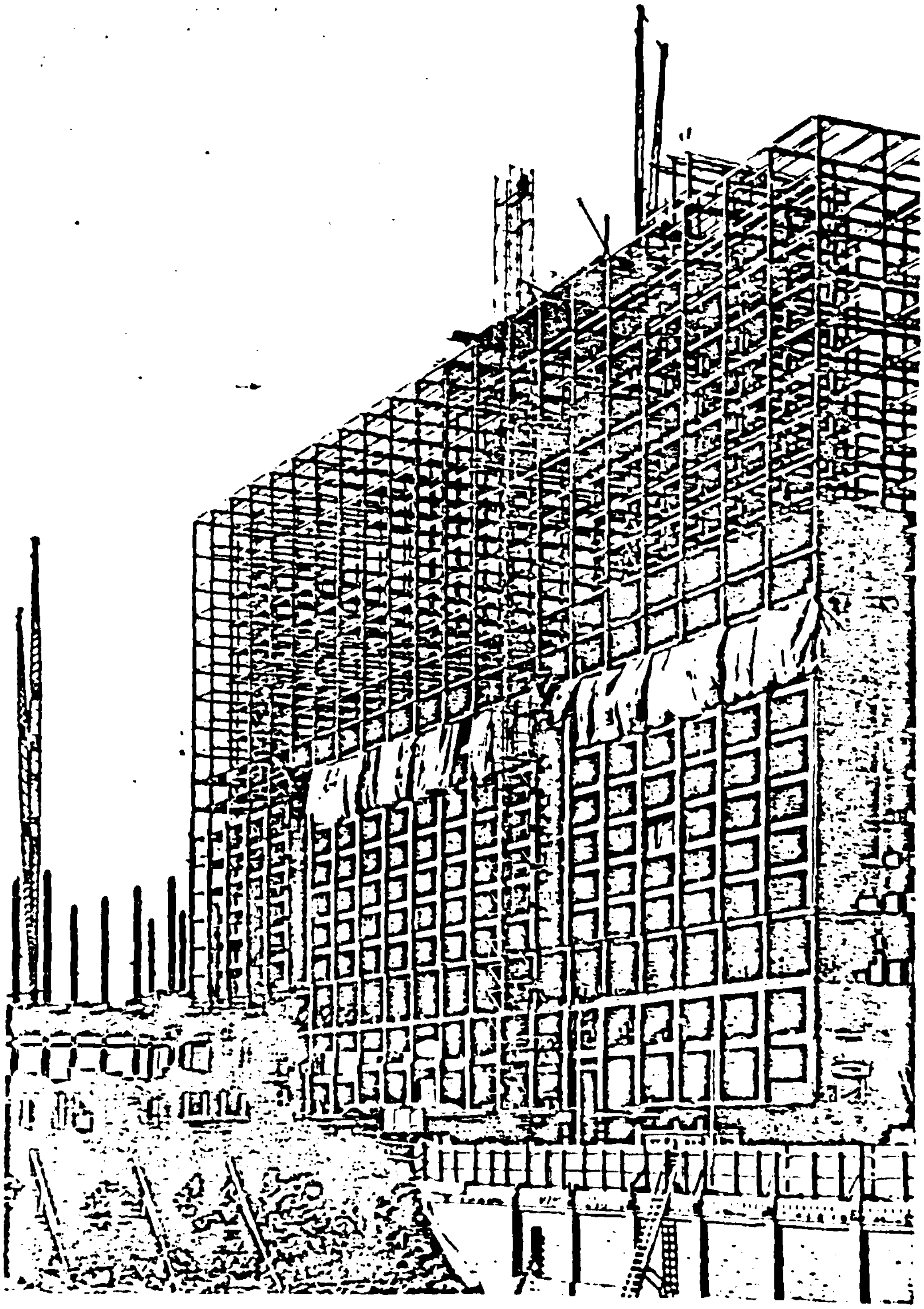
Another option is to bring medical personnel and equipment and set up care facilities on a specific floor or floors within the structure. Consideration may be given to transport casualties via rope or cable strung between buildings that still have internal conveyances operating.

Transporting casualties via stairwells may be necessary either between floors, to the roof, or to ground level. However, it will take four rescuers to transport each stretcher casualty via stairwells.

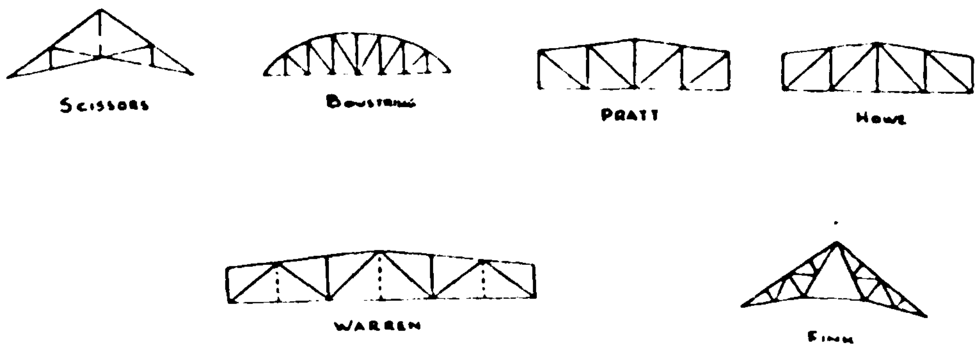
As identified, there are several methods for treating, moving to a safe refuge, or evacuating occupants and casualties of a high-rise incident. A combination of methods will probably be used in any incident. It is essential that a plan be developed, coordinated, and controlled by an established incident command system. Communications, internal and external, or a combination of both, are necessary for any effective large-scale rescue.



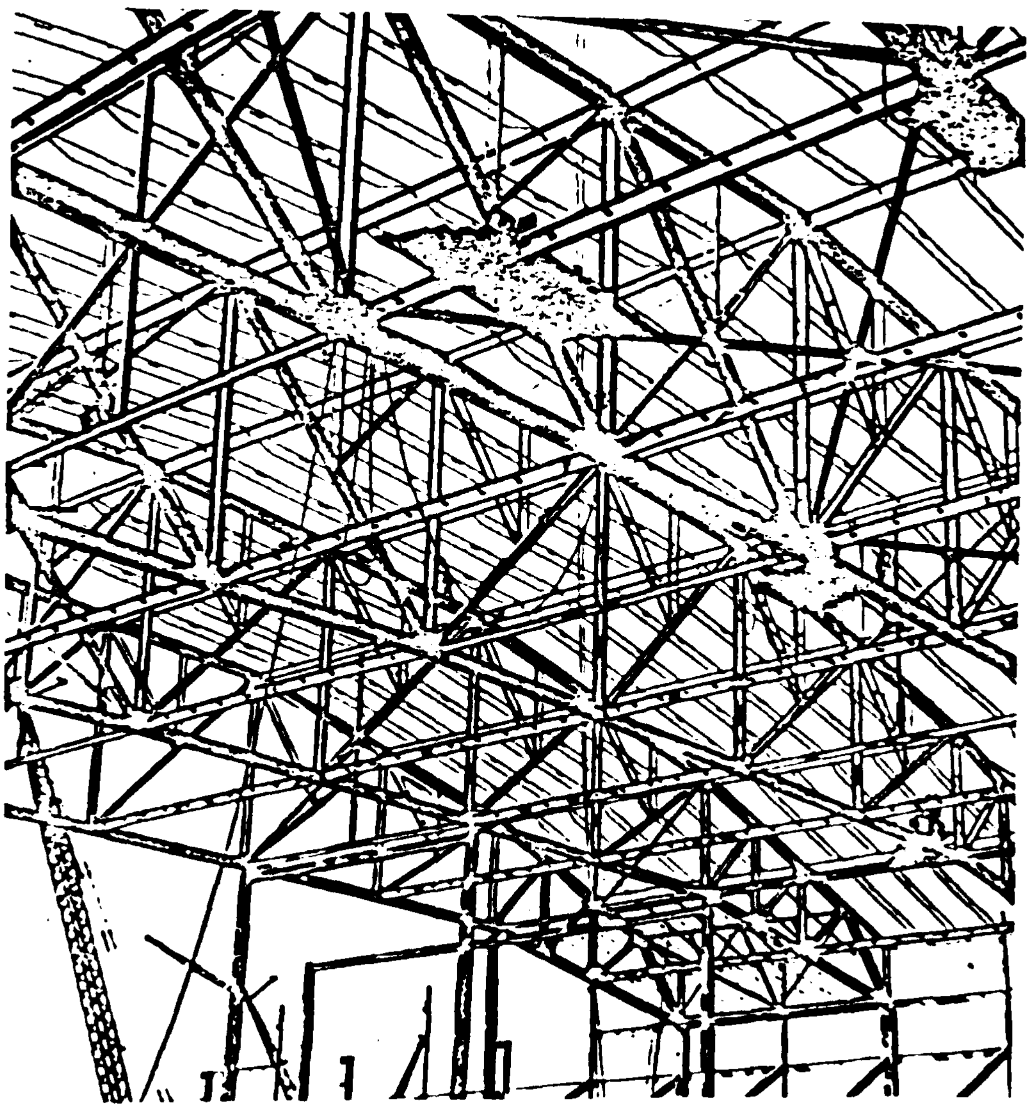
METAL FRAME WITH METAL (TRUSS) JOISTS



COLUMNS IN A STEEL FRAME BUILDING

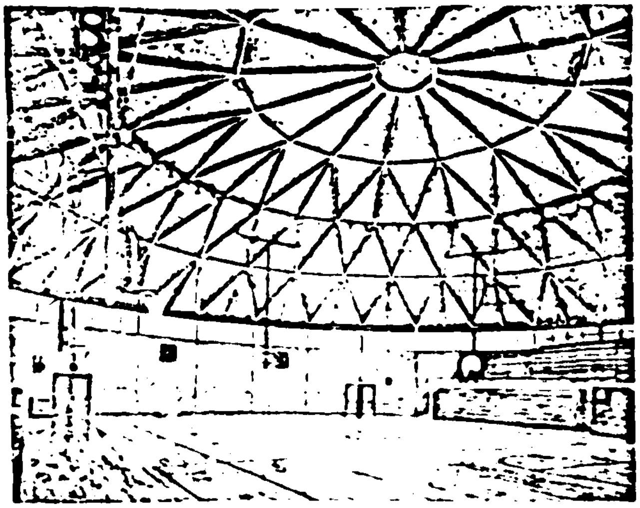


TYPICAL TRUSS CONSTRUCTION

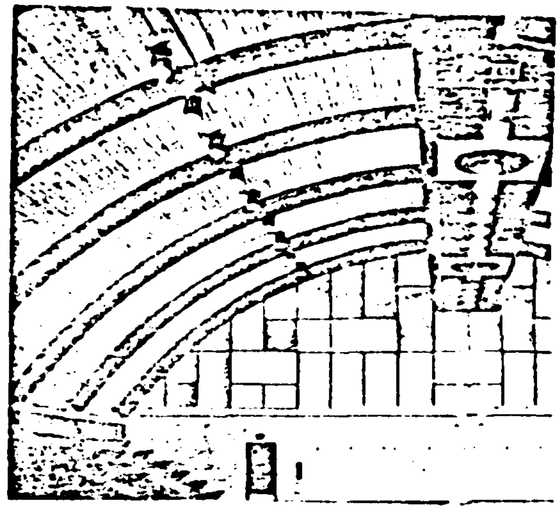


ROOF TRUSSES ON STEEL COLUMNS

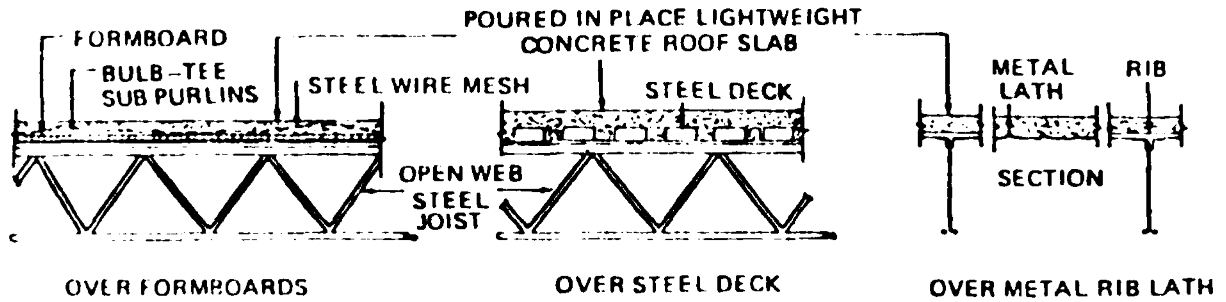
ROOF CONSTRUCTION



ARCH ROOF



DOME ROOF



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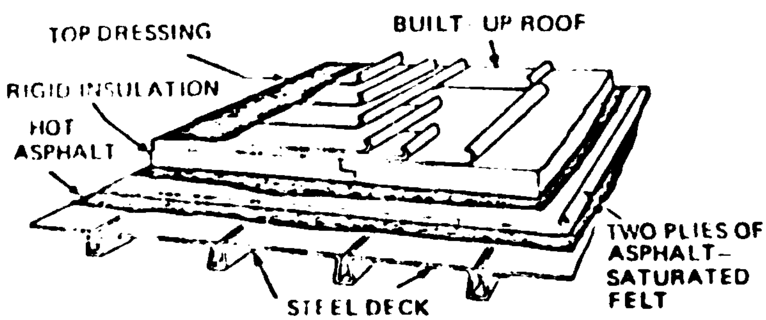
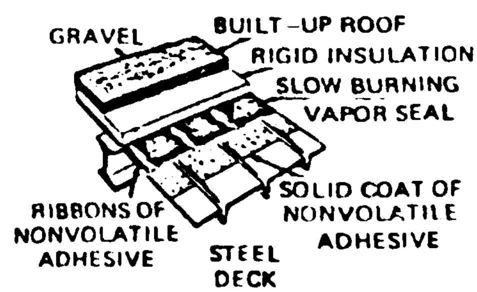




STEEL USED IN ROOF CONSTRUCTION

PATIENT ASSESSMENT

In a disaster with multiple victims, a method of patient evaluation or assessment is needed to allow the rescuer to determine the life-threatening injuries quickly. One method is called "the 30-second physical."

It is very important that the rescuer have a system which allows for the systematic evaluation of a victim. This assessment must be a "hands-on" type where the rescuer actually covers the victim with their hands from head to toe.

The number one priority in victim assessment is breathing. This must be checked first. Due to the position of the victim, it may be necessary to rely totally upon the sense of feel to determine if the victim is breathing. The back of the hand is best. One has to be careful not to confuse breathing with body heat.

One suggested method of evaluation is to start at the head, checking breathing, the ears for fluid, and the skull. Next the neck is checked for deformity. The torso is then checked, including the rib cage and the abdominal cavity. The hands are slid up the back to locate any bleeding or deformity. The upper extremities are checked next. Usually this can be accomplished from one position. The pelvic area and lower extremities are checked next.

It is extremely important that the rescuer have a system of victim evaluation. If a life threatening situation is found, it must be taken care of immediately. If the rescuer does not have a system, the care of a life threatening situation may end the assessment, and another injury may be overlooked. With a system, the rescuer knows there are certain items which have to be accomplished; and even though he varies from his system to handle a life threatening situation, he returns to the assessment and completes the evaluation. Life threatening situations are breathing and life threatening bleeding. If these situations can be handled, the rescuer has gained some time to properly remove or transport, or extricate the victim.

ENVIRONMENTAL

Snow, Ice and Cold

During snow, ice and cold spells, everything from roads to tools becomes covered with ice, making heavy rescue extremely treacherous. Sand carried by the rescue team can be used for traction of the response vehicle as well as reducing the slipping of such rescue tools as jacks.

Hypothermia and the fact skin will stick to extremely cold metal are two of the problems frequently overlooked by rescuers not accustomed to this type weather condition.

Blizzard conditions can not only cause persons to become trapped, but cause some persons to become hysterical, adding to the rescue problem. (Example: during heavy snow storms on Donner Summit, California, the Highway Patrol is frequently called upon to drive personal vehicles because the drivers have been overcome by claustrophobia.)

Fog

The biggest problem for the rescuer caused by fog is the nearly total loss of visibility and sense of direction. Not only does fog reduce response time and increase search procedure difficulties, it also subjects the rescuers to the very real possibility of becoming a victim themselves. Rescuing persons from major traffic accidents in the fog is probably the most dangerous situation a rescuer will face.

Smog

The most serious problem faced by rescuers due to smog is the number of persons requiring assistance. Heavy smog alerts cause an overwhelming number of people to have respiratory and eye problems. This causes the hospitals and other medical care facilities to become overcrowded. During these conditions if the power goes off, many people relying on filtering systems soon become additional victims that require attention. These conditions will cause the rescuer to become overtired or careless in carrying out the rescue operations required, adding to the problem.

Fire

When we think of fire in the rescue of persons, we generally think of entering burning buildings, locating victims, and removing them from the building. In this manual we will consider fire as an environmental problem. The majority of rescuers do not consider the problems faced during large fire situations such as those faced by the Southern California area almost yearly, or the conflagrations in Chelsea, Massachusetts. With today's construction of multiple-family dwellings in large clusters, we are beginning to read more and more of the loss of entire apartment complexes. The rescuer must plan for the mass evacuation of residents from the fire area. In most cases the evacuation of residents will be over the same roads the rescuers and fire suppression forces are using to enter the area for rescue/fire fighting operations. High rise buildings present a complex and difficult rescue problem. Rescuers have been faced with victims jumping from burning buildings due to loss of escape routes.

In recent years rescuers have also been faced with the task of performing rescues in areas set on fire by transportation accidents. Most of these accidents did not occur in areas where pre-plans could have or were made. The rescuer must be prepared for working in large areas where fires exists. A general pre-plan can be made by following the many guidelines for disaster plans which are available.

In general, only rescuers with aknowledge of fire behavior should carry out rescue operations in the immediate area of major fires.

Wind

Seldom do we encounter problems with wind alone. More often than not, winds are accompanied by blowing dust, sand, rain, hail or snow. For the purpose of this manual we will attempt to consider wind as a single factor to be dealt with during heavy rescue problems.

Winds of relatively low velocity (35 to 60 mph) have been responsible for 80% of all wind damage, but only 38% of the dollar loss reported by Factory Mutual, according to "The Officer's Guide to Disaster Control," a publication by Charles Bahme.

Winds alone can cause rescuers problems when searching for victims in large or major rescue situations. Wind will limit voice communications between rescuers or rescuers and victims. It may become impossible to hear victims making sounds in windy conditions. Winds will carry dust or debris which will limit visibility and may cause eye damage to rescuers not properly protected. Hazardous or toxic materials may be spread farther or faster than rescuers can move ahead. During lifting or raising operations the wind can cause the loads to become unstable. Winds also make vertical rescue extremely dangerous or impossible.

Rain

Rain can create problems for the rescuer ranging from uncomfortableness to life threatening. The least problem is that rain will cause the road and other surfaces to become wet and slippery, delaying response to and rescue of victims. During rainy weather rescues, the rescuer is made uncomfortable due to being wet or by the additional protective clothing necessary to stay dry.

On the other end of the spectrum of problems caused by rain, rescuers face the possibility of heavy flooding of low lying areas and the saturation of hillsides to point of mud slide. Heavy rains can cause rescuers to perform white water rescues.

Tsunami

Tidal waves in the United States have wrought destruction as far as one mile inland depending upon local topography. These waves can carry ships, buildings and other debris with them, blocking access, collapsing structures and destroying communications and normal utilities and sanitary services.

Earthquake

Earthquakes range in intensity from light to severe. Building collapse and instability are the main products of earthquake. Secondary effects include local utility, communication and transportation destruction. Earth cracks form typical problems as do landslides and sections of land rising and falling as much as 24 feet in some cases. Access routes involving bridges, roads on mountain terrain, tunnels and road cuts may be considered prime targets of earthquake. In addition to physical destruction, health hazards are great due to leaking or nenexistent sanitary systems. Domestic water supply may also be destroyed, inhibiting fire fighting/rescue. Failure of water tanks or reservoirs may cause flooding destruction like that of tsunami.

Landslides

Quite similar to earthquakes and frequently caused by them, are landslides. Landslides provide the same inhibitors and problems as earthquake with roads and bridges being made impassable. Other than earthquakes, landslides are also caused by heavy rain or soil moisture. Landslides of this nature often bury cars and structures intact, trapping persons in voids. Digging in moisture-laden soils is also tricky as there is still the tendency for much settling. Shoring for excavations will have to be stronger due to the unstability of the land or mudslide. Methods which act to drain off moisture will vastly improve the consolidation of the soil.

Avalanche

Avalanches are actually snowslides and produce similar disruptions as do landslides. There are two major types of avalanche - Powder and Slab. Slab is the most dangerous and destructive.

Powder avalanches can occur on steep slopes after heavy snowfall of over one inch per hour on a consolidated snow surface of over 25°. Slab avalanches are produced by the instability of alternate layers or slabs of frozen snow and ice mixed with light powder snow. This type avalanche propels large blocks of hard ice within its mass, crushing and smashing with considerable force. Slab avalanches start due to activity on the snow such as travel and wind or warning/ cooling cycles rather than depth instability.

When avalanches are in motion they are relatively fluid, but quickly freeze solid the moment they stop. Persons buried in snow avalanches can survive for up to one hour in some cases. Avalanches often occur in the same locations year after year. Look for bare hills and gorges as well as foliage which appears bent.

Volcanic

Problems of volcanic activity are thought to be only associated with the South Seas Islands. However, volcanic activity and potential exist throughout the entire Western United States and Mexico. Volcanic activity produces three major problems, the least of which is the molten magma or lava. Usually volcanic activity is proceeded by an explosion which forces gas and ash into the air, reducing visibility and forming a smoke-like inversion in the atmosphere. The possibility now exists for a collection of flammable and toxic gas under this inversion. The danger is both from the toxic gas and the very real possibility that this same gas may ignite into a massive fireball or cloud, miles in diameter and which has been known to travel miles over varied terrain. The final risk of volcanic eruption is in an active eruption cycle interrupted by the closing of the lava and gas vents. The diverted energy can now trigger an explosion which will violently render the surrounding landscape for tens of miles to dust.

There is very little man can do to prevent or diminish volcanic damage except to evaluate residents and keep the curious a safe distance away. Once volcanic activity has subsided there exists much instability, and lava flows in particular may remain fluid and dangerous beneath the surface which may have crusted over.

Ventilation - Air Movement

The term "ventilation" as used by fire fighters means the planned and systematic removal of smoke, heat and toxic gases from a structure, vessel, space, or area to assist in saving lives and property.

Proper ventilation on emergency incidents requires knowledge gained from practical experience as well as an awareness of the effects of the reaction taking place, such as combustion, chemical reaction, chemical release, how these affect life and property, and what effect weather and structural conditions have on the incident.

There are numerous reasons to provide ventilation on emergency incidents:

- Save life by removing smoke and gases endangering occupants who are trapped or unconscious.
- Discover exact location of fire, leak, or chemical reaction.
- Allow rescuers to enter an area and operate effectively in search, rescue and extinguishment, or gain control of an incident.
- Prevent backdrafts or smoke explosions.
- Control spread of fire, chemical leaks or chemical reactions.

Fire fighters are familiar with resources used to accomplish ventilation such as axes, saws, power tools, power driven fans and fog nozzles. They should also be familiar with air handling systems in structures, vessels and spaces.

On incidents requiring resources for air movement which exceed those regularly available, fire fighters should identify those agencies in their area who may be able to provide additional air movement resources. These resources should be obtained from other services through the proper officials. These may include utilities, manufacturing, construction mining, petroleum, shipyards, aircraft plants and service facilities, and chemical industry or movie studios. In all cases, check local, county and state mutual aid resources.

PERSONNEL LIMITATIONS

Physical and Psychological Aspects of Rescue

An emergency can happen to anyone, at almost any time. One doesn't have to be in an airplane crash or marooned on a desert island to face an emergency. Any and all aspects of heavy duty rescue are potentially times of heavy stress and great psychological duress. When an unexpected, life threatening emergency arises, problems must be faced with what is available, wherever we are, depending entirely on ourselves and our team mates. Even when everything else is lost, we still have a body, a brain to help solve problems, and whatever resources might be available. Response to emergency depends on education, experience, and ability to combine both in times of stress.

Survival is nearly 100 percent mental because the mind controls the body, not only through reasoned actions, but through voluntary and involuntary muscle control which keeps us functioning under stress. Conscious and unconscious mental functions are of utmost concern to the survivor of a heavy rescue situation as well as the rescuer. The greatest obstacle to survival will probably be mental. Since survival is nearly 100 percent psychological challenge, our brain becomes our most important tool. Recognizing body needs and acquiring such always requires thinking and problem solving based on education, experience, and training.

Positive mental attitude is essential for survival. We must want to survive and we must approach heavy rescue situations with the idea that others want to survive. Nothing is more useless than to try to motivate rescuers to search and rescue efficiently and productively when they think they are looking for deceased victims.

Conscious fear results from a recognized situation or from expecting impending disaster. Fear at an unconscious level creates feelings of uneasiness, general discomfort, worry or depression, usually called anxiety. Fear and anxiety vary widely in intensity, duration, and recurrence. Effects on behavior range from mild discomfort to

complete disorganization and panic. Most people experiencing fear or anxiety magnify the unknown. Training, including knowledge and experience gained in simulated emergencies, reduces the unknown and helps to control fear. Fear may control behavior until we react to feelings and imagination rather than to the problem. When fantasy distorts a moderate danger into a major catastrophe, behavior can become abnormal. In such cases, we usually underestimate rather than overestimate danger, leading to reckless, foolhardy behavior. The best way to fight fear is to meet it head on. Recognize fear as a natural phenomenon; try to establish exactly why fear originated and accept the fact that fear is just another obstacle that can be overcome. There are no sharp lines between recklessness and bravery, caution and panic; it is essential to maintain proper control.

"Controlling Fear in Ourselves" (copied from "Emergency Preparendess Today," Robert 'Skip' Stoffel, Survival/Disaster Education Coordinator, State of Washington).

- Don't run away from fear. Recognize, understand, admit, and accept it. Learn what reactions are likely to be.
- Learn how to think, plan, and act logically, even when afraid. Take positive action to control fear.
- Develop self-confidence. Increase capabilities by keeping physically and mentally fit; learn all you can about survival and how much stress you can stand. You can stand much more than you think.
- Be prepared. Realize "it can happen to me." Be prepared to cope with the worst.
- Keep informed. Be alert to danger and be prepared if it comes; increase your knowledge to reduce the unknown.
- Keep busy. Strive to prevent hunger, thirst, fatigue, idleness, and ignorance about the situation, because these increase fear.
- Know how your comrades react to stress. Learn to work together in emergencies to live, work, and plan as a team.
- Cultivate good survival attitudes. Concentrate on your main goal and keep everything else in perspective. Learn to tolerate discomfort. Don't exert yourself to gain minor desires which may conflict with your overall goal to survive.
- Cultivate mutual support. Teamwork reduces fear while making each person's efforts more effective.
- Use leadership. The most important test and greatest value of leadership lies in the stress situation.

- Practice discipline. Attitudes and habits of a disciplined group have a better change to survive.

- Use contagion to advantage. Calm behavior and self control are contagious. Both reduce fear and inspire courage.

Fear is a normal reaction to danger. Fear can be overcome by understanding through training, knowledge, reducing the unknown, and by effective group action. Fears are normal in unfamiliar situations. If aware of them, we will be able to cope as they appear. Fears unexpected in any survival situation include fear of the unknown, discomfort, being alone, suffering, death, darkness, heights, small places, water, etc.

Fear of being alone can be very serious. Thinking about never hearing another human voice can weigh heavily on a person's mind. Being trapped under a collapsed building would be such an occasion.

Fear of darkness is inherent in most individuals. Darkness blinds and immobilizes us, and hides all familiar things. Darkness sometimes can stir imagination into disabling fear. Again, the example of being trapped in a collapsed building, a mine tunnel, etc., is very dramatic, not only for the rescuee but for the rescuers as well. The fear of darkness for the rescuer needs to be very significantly appraised by the rescue party.

The fear of high places and fear of tight places are other areas which are potentially very dangerous or at least uncomfortable. It is ridiculous for a rescuer to be involved in a high rise rescue, a mine rescue, or other type incident involving extensive vertical work if the rescuer is overly afraid of the work. The same is true for working in tight places such as a mine cave-in, under a collapsed building, etc. In both situations, there is a paramount need for the rescuers to understand their abilities and limitations and also to appreciate the problems that the victims of these incidents may be going through themselves.

Limits of Law Coverage

No text can take the place of competent legal advice on a specific problem within a given jurisdiction. For supplying guidelines there are several books available for information which include: "Fireman's Law Book" by Charles W. Bahme; "Introduction to Fire Protection Law" by D.L. Rosenbauer; "Fire Related Codes, Laws, and Ordinances" by Vince G. Clet.

Rescue members must be familiar with the legal aspects which affect their authority as it applies to rescue work and good samaritan laws, salvage work, medical assistance, first aid demolition, liabilities, insurance, jurisdiction, out of jurisdiction command and control responsibilities, negligence, and common law inlet.

During times of a local emergency, state of disaster, or national emergency, governing bodies may provide additional legal authority which will affect and enhance rescue operations and resources. These laws, ordinances, and regulations are promulgated and put into effect upon declaration by the appropriate executive office. Rescuers should be familiar with these laws and how they affect their operation prior to any incident so they may react accordingly.

SPECIAL TOOLS, EQUIPMENT AND RESOURCES

Some incidents may require special tools, equipment and resources not carried on fire apparatus or rescue vehicles, helicopters, etc. Many agencies recognize this need and have identified those other agencies who have these resources, and obtained commitments from proper officials to use these resources on emergency incidents.

The priority of use of other agencies will vary due to time and nature of emergency, as well as availability of resources. Agencies who may have special tools and equipment include:

- Local government services
- County government services
- Region government services
- State
- Federal (RCC Center)
- Private industry

Local agencies should maintain lists of resources and availability. These resources include:

- Rescue Specialist/Advisor Team(s)
- Bulldozers
- Cranes - size/type
- Loaders
- Dump trucks
- Vacuum trucks
- Pavement breakers
- Pneumatic tools
- Generators
- Draglines
- Gas detection equipment
- Breathing apparatus
- Air line respirators
- Cutting and welding equipment
- Electric flood lights
- Hazardous materials handling kits
- Aircraft
- Foam and foam making equipment
- Power saws
- Safety equipment

This equipment is available via contractors, dealers and government agencies. Costs for use may be levied for any of the above items. Therefore it is critical that anticipated equipment resources be outlined and maintained well in advance. Remember, it is far better to cover as wide a range of materials as possible, rather than what seems just adequate.

P A R T   T W O

USE OF ROPE IN HEAVY RESCUE

Use of tools, equipment and materials should not be limited by the scope of application experienced in this manual. Consideration must be given for the use of equipment, materials and tools in substitution of those utilized for specific application in this manual. Materials, tools and other resources found at the incident scene must often be employed to achieve the goal of rescue. Complete and thorough training in use of tools as well as continuing skill level maintenance training is essential. Necessity is the mother of invention -- improvisation is necessary for effective rescue.

Ropes, Knots and Rigging for Heavy Rescue

Rope uses in heavy rescue can be divided into ghree general categories:

1. Life lines
2. Haul lines
3. Utility lines

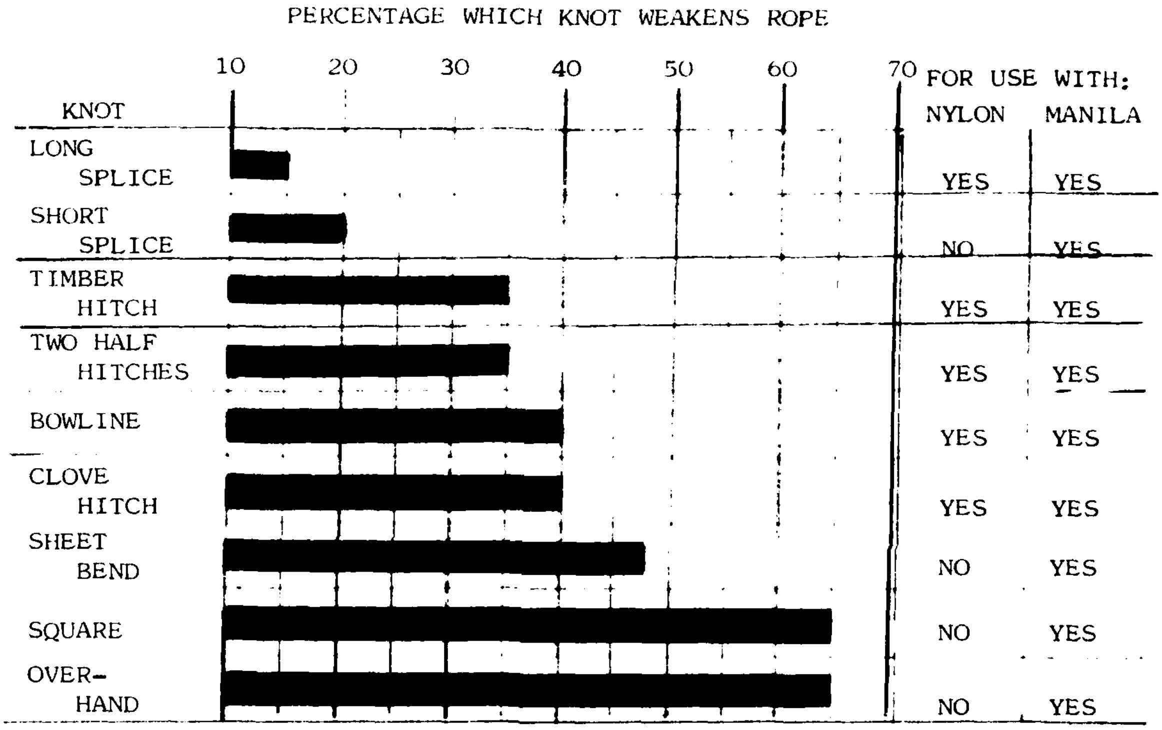
Life lines are ropes which are used in the raising or lowering of human life. Pulley systems which are lifting objects off of human life would also be covered in this classification. In short, if the failure of the rope will result in death or injury, then a life line quality rope should be used. Generally nylon is the best choice for a life line. Life lines should be reserved for life safety uses only and identified as such.

Haul lines are considered lines which are used in pulling, lifting, and hauling any objects or equipment not related to human life, and whose failure would not result in injury or death to users or victims. Haul lines may be identical to life lines except they will be subject to more use/abuse in normal operations which can render them less reliable.

Utility line is best classified as a rope or line used to lash or secure loads or rigging in place. As a general rule, life and haul lines are under live or active forces while utility line would be under static or fixed forces. Seldom do utility ropes have more than static, evenly applied forces on them.

One of the most overlooked aspects of rescue is that of rope. The quality of ropes generally in service today is poor, considering what is available. Ropes, for the most part, are bought like a "pig in a poke." This is due to the fact that most people do not know what they need in a specific type rope. The purpose of this section is to briefly explain what to look for and what to expect from rope.

THE EFFECT OF KNOTS AND SPLICES ON ROPE TENSILE STRENGTH



Properties

Tensile Strength - This is the static force required to break the rope. It is not an indicator of how strong the rope is.

Working Strength - Working strength is generally computed to 1/5 the current tensile strength of a rope. It is the maximum load, not force, which a rope can support without sustaining great damage. However, with each use, the rope declines in strength, so tensile and working strength are never constant.

Energy Absorption - This is the shock absorbing quality of rope, or how much force a rope can take suddenly without breaking. Steel cable, for example, is high in tensile strength, but has little or no energy absorption and will snap when a very small weight is applied suddenly. It can easily be seen that elasticity is actually the best measure of a rope's total ability and performance. However, the force applied should not exceed the rope's working strength. It should also be noted that if an elastic rope is loaded to 50% of its tensile strength 12 times in succession, it will fail; and after 70 loadings at only 25% of tensile strength. This is due to elastic fatigue. With a proper interval of rest, repeated loading can be accomplished safely.

Safe Life - This is the total life of a rope as subject to ultra-violet radiation, moisture, abrasion, and number of days in use. The most important of these is the compound abrasion and days in use. With natural fiber there is no safe life, since the rope starts to deteriorate from the moment it is made. Therefore, natural fiber ropes should never be used in conjunction with human life, since their life is totally unpredictable. However, with synthetic fiber or yarn, the rope's life is very predictable, particularly for static kernmantle rope.

Quite recently, research has shown that nylon rope deteriorates in direct proportion to the number of times it is used; the abrasion factor from this use being the constant with nylon of laid construction. There is one exception however -- when a rope has been subjected to a force which will elongate it 20% to 30%, its useful life is finished and it should be retired no matter how new it is. In addition, once a rope sustains a load equal to 50% of its total tensile, it should be downgraded to a non-safety rope.

Strength of Application - This is the tensile strength, less the percentage of knots or bends. Every angle potentially weakens a rope. For example, a rope rated at 10,000# tensile strength which is secured by a bowline to an object, will fail at 60% of the rope's strength; in this case, 6,000#. The strength of application does not, however, affect the working strength, as the percentage of tensile reduction is potential only, and the rope incurs no adverse effect.

Construction

Laid Rope - Laid rope is the most common form of rope today. It is made by twisting a number of fibers into a single strand and then "counter twisting" three strands into the finished rope. This structure is very strong, but is very prone to abrasion. In the twisting during construction, about 80% to 90% of the entire fibercount is exposed at the surface. This leaves only 10% to 20% of the rope protected. The most recent research has determined that even ropes which are mildly abraised have been found to be only partially intact. This greatly affects the energy absorption quality of the rope since synthetic rope relies on its continuous fiber structure, which travels uninterrupted the entire length of a rope. (Natural fiber ropes are made of short, spliced fiber and therefore are not very elastic.) On a 3-strand lay rope, the 3 strands only provide 2/3 of the total rope's strength. Failure of one of the 3 strands will cause the rope to lose 2/3 of the rope's total strength.

Since laid rope is produced by twisting, it has a nasty habit of kinking when force is applied. The structure is actually much like a giant helix. As force is applied, the helix tends to straighten out and unwinds a small amount. When this unwinding reaches its maximum, the rope is very brittle since it depends on the close support of the other strands for strength.

Because laid rope is a twisted product, it should not be used on devices which tend to additionally twist it, such as the life belt or sky genie. Whenever a man employs this device or those similar, the rope will kink and snarl rapidly below. When the same man is free of the wall he will spin so rapidly that in many cases, he will become sick and possible black out. Most rescue devices now in use by the mountain rescue agencies employ a friction brake device called a brake bar. This tool has all the features of the life belt, yet does not twist the rope. It is also considered the best tool for lowering stretchers, men, and equipment.

Braided Rope - This rope is formed by a weaving process which joins a dozen or more substrands into a solid braid. The finished rope is a rather loose weave and subject to heavy abrasion. On braided rope, 100% of the fiber is exposed to abrasion. Also, its elonation is excessive and is currently used only for ropes where dirt and grit are at a minimum. Braided rope, despite its drawbacks, is very good on capstion style winches due to its soft nature and large surface-contact area. Braid-on-braid ropes consist of two unconnected braids, reducing the total abrasion of fibers to 60%.

Static Kernmantel - Quite different from dynamic kernmantel used for mountaineering, this rope is a tight mass of synthetic fiber which is placed under tension in a woven jacket or sheath of like synthetic fiber. This construction results in a no-stretch, no-kink rope such as braided or braid-on-braid, yet with 85% of the fibers protected by the woven sheath. Unlike braid-on-braid, the sheath on static kern-mantel will not slide on the core, thus, static kernmattel rope is the most abrasion-resistent rope yet developed. Abrasion will seldom ever exceed 20% of the entire fiber count.

Static Kernmantel has less than 2% stretch under normal loads, yet if impacted, possesses very good energy absorption. For this reason, Static Kernmanetl is very useful in the hauling or lowering of critical men or equipment loads or where a no-stretch, high strength rope is needed yet (unlike cable) able to absorb energy without breaking.

Natural Fiber Ropes (Cotton, Hemp, Sisal, etc.) - These ropes are all vegetable products and as such, start to deteriorate from the day they are harvested. They have no safe life. Their use in heavy rescue should be very limited and on non-critical items, a human life should not be trusted to natural fiber ropes except as a last resort.

In order to test the quality and relative strength of ropes, they should be inspected visually each month. Important conditions to be looked for are:

- Surface abrasion, broken fibers, brittle fibers, etc.
- Soft spots.
- Wet or mildewed areas (possible discoloration).
- Internal abrasion as mentioned above.
- Dirt or powdering along the strand axis.
- Cuts in sheath, to core, on kernmantle.

Visual inspection should not be limited to the surface of the rope. The strands must be twisted apart and examined most carefully. If in doubt about the condition of a rope, take several lengths of fiber from the rope and run them across the fingernail. If they feel brittle and dry, the rope should be sent to be tested at once.

Each year all ropes should be tested by static means to 10% above the rated working strength. Synthetic fiber ropes should be washed in warm water after use to rid them of abrasive dirt and grit.

DO'S AND DONT'S CONCERNING ROPE

DO train frequently on rope uses
DO keep clean
DO keep coiled
DO test and inspect frequently
DO pad abrasion points rope may run over
DO identify rope type/classification

DON'T stand or step on rope as this drives dirt deep internally.
DON'T let oil, grease, acid, alkaline materials come in contact with rope.
DON'T test rope more than it's working strenght plus 10%.
DON'T use strong cleaners or solvents on ropes.

The selection of a specific type rope for a task is an extremely important item, critical many times to the operation. The following is a brief outline of properties and qualities of common rope materials.

Manila - Manila will not stretch and hence will not absorb impact or shock load. Water, chemicals and heat will degenerate manila rapidly. Good abrasion resistance; good in sizes larger than 1/2" diameter for haul lines and utility line or sling; and should not be used as a life line unless the rope is new.

Nylon - (Dynamic or stretchable style). Good for all rigging, slings and life line where sudden or high impact loads are anticipated. Dynamic nylon has long been used as a protection life line for mountain climbers. This dynamic property will, however, cause high stretch at rather low loads -- as much as 10-20% at 200# and therefore may not be desirable for lowering loads where the load may be increased or decreased during the loader or raise. Good heat and chemical resistance compared to manila. Fair abrasion resistance.

Nylon - (Static or nonstretchable). Best for life lines as it possesses extreme strength, some impact or energy absorption, and has proven ideal for raising and lowering mean and variable loads. Good heat and chemical resistance. Excellent abrasion when in kernmantel construction. Good in lay or braid construction.

Dacron - Same as static nylon except has less abrasion resistance and even less energy absorption. It is a good lifeline and rigging rope; however, nylon does have an edge. Good chemical and heat resistance.

Polyethylene/Polypropylene - Not desirable for rescue due to low strength, high stretch, low temperature resistance. Avoid for heavy rescue where weight or life involved.

Sisal - Similar to manila except it possesses overall weaker strength.

Cotton - Not an acceptable material for life line; and depending on small diameter, may not be acceptable for slings or haul lines. Qualities much the same as manila.

KNOTS

Prusik Knot - This hitch is commonly referred to as a "knot" by many. In normal practice it is used to tie a smaller rope, usually in the form of a loop or sling, onto a larger rope. It grips the main rope very securely if under tension, but is easily slipped along the line

if the pressure is released. If pliable small slings are used such as a 5/16" loop on a larger pliable rope, the knot grips without trouble. If a hard-laid rope of larger diameter is used, such as a 7/16" sling on a 7/16" rope, it may be difficult to get the knot to conform to such a relatively small diameter. If a spun-nylon, hard-laid rope becomes wet, it stiffens and the knot may fail. This is due to a change of frictional qualities. Dynamic nylon makes a prusik knot which will have the tendency to stretch and jam -- static nylon does not.

Much of the tendency of a prusik to slip is due to the 90-degree angle between the needed tightening force and the load line. If, when setting the prusik the thumb is placed against the knot while the fingers grip the sling, it is possible with almost no effort to tighten the knot as the load is allowed to come onto the line. If this first snubbing friction is applied, the total load will further tighten the knot when it is added.

When under pressure the knot has been known to "slide" when a force of 1500 pounds has been applied. This figure may be more or less dependent on the diameters and pliabilities of both ropes involved, and the coefficient of frictions of the larger rope; i.e., wet, ice, mud, etc.

The prusik knot has many applications. It has been used to ascent the standing part of the bigger rope; to "hold" loads in hauling systems' to tie something onto a rope in the middle of the rope, etc. Generally speaking, a two-wrap prusik will suffice for most situations. A 3-4 wrap prusik will increase gripping power for wet, iced or high load situations.

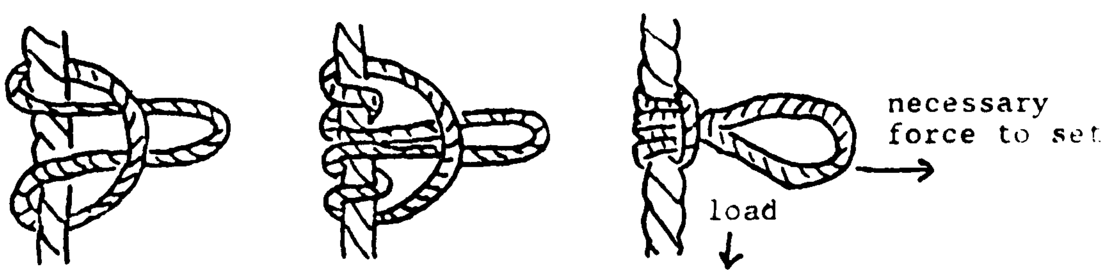


Figure-8 - This knot has many uses. It can be used at the end of a rope to keep the end from running through a block. It can be used at the end of a rope to hook into a carabiner. It is very handy in the middle of the rope to hook objects or people into without the need for the end of the rope. It does not injure the rope and is easily untied.

Figure of Eight (8) Loop (on a bight)

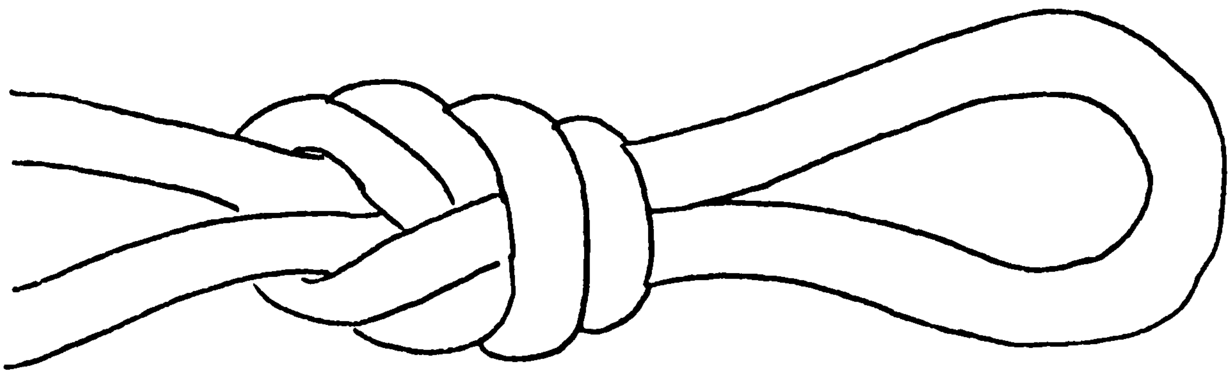
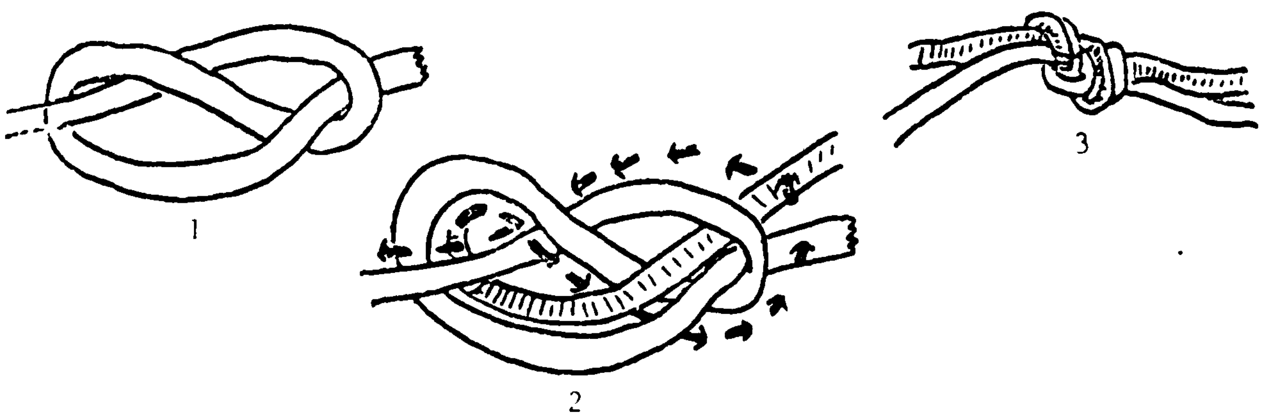
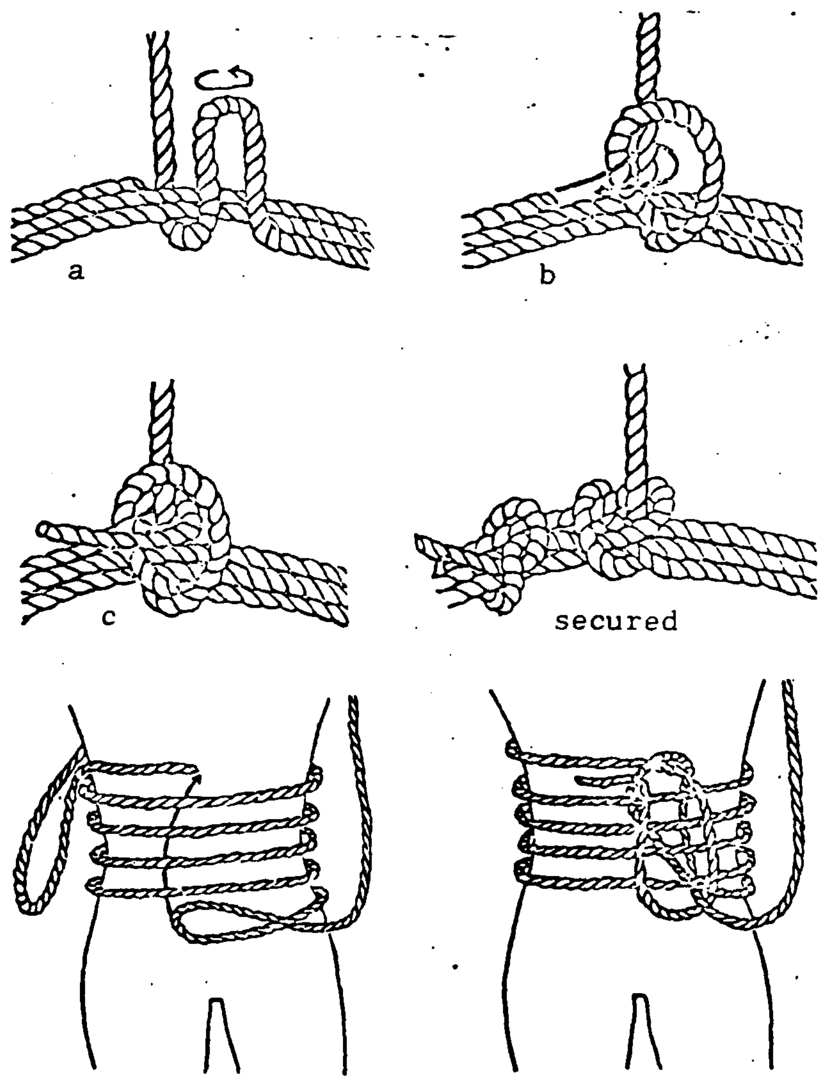


Figure of Eight (8) Followthrough

This knot is most used to tie both webbing and two ropes together. It is possibly the strongest of the most common knots for this purpose.

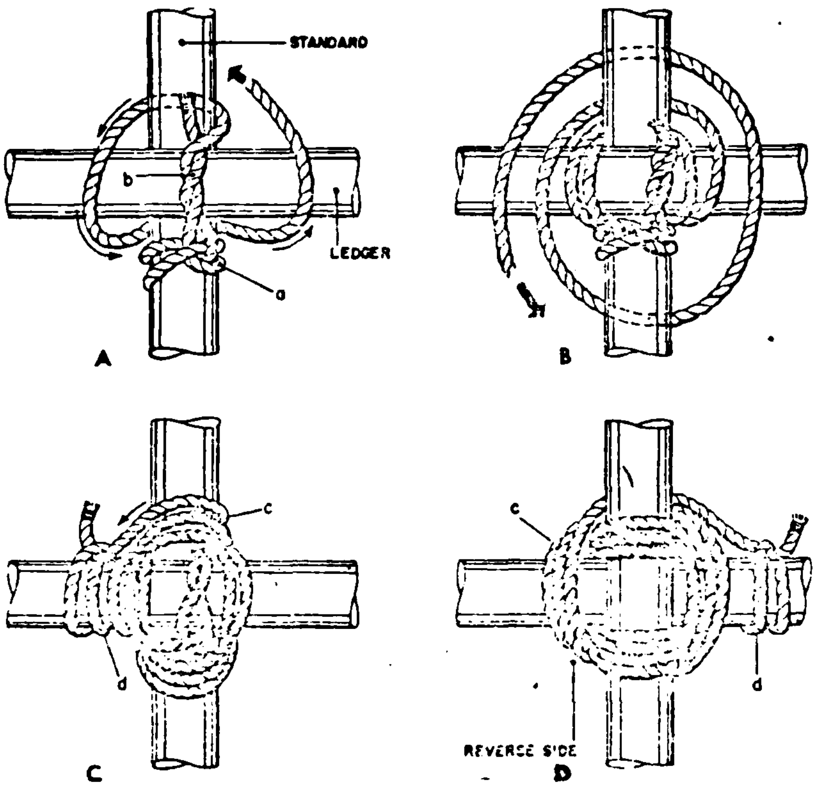


Bowline on a Coil - Like all bowlines, this knot has many applications. The two most likely to be encountered in heavy rescue work are to secure a litter and to tie a person onto the end of the rope. The bowline on a coil is adjustable so the two loops formed can be made larger or smaller depending on the need. As these loops are made larger or smaller they will tilt the stretcher to one side or the other. The other positive aspect of this knot is that when it is passed around a tree or a person, the loops tend to self-equalize and therefore distribute the weight. This is very important when deal ng with a human form. Mountain climbers tend to use this knot heavily because of the weight distribution quality. In mountain climbing terminology, this system is called a "swami belt." It can be tied from the end of a long piece of rope or it can be tied onto the person's body utilizing a short (20') piece of rope or webbing material.



LASHINGS

Generally, lashings are used to bind two or more objects together. Personnel should understand and practice lashings until they become thoroughly proficient in their use. Suitable lashings can generally be made with a length of 5/8" rope.



Square Lashing

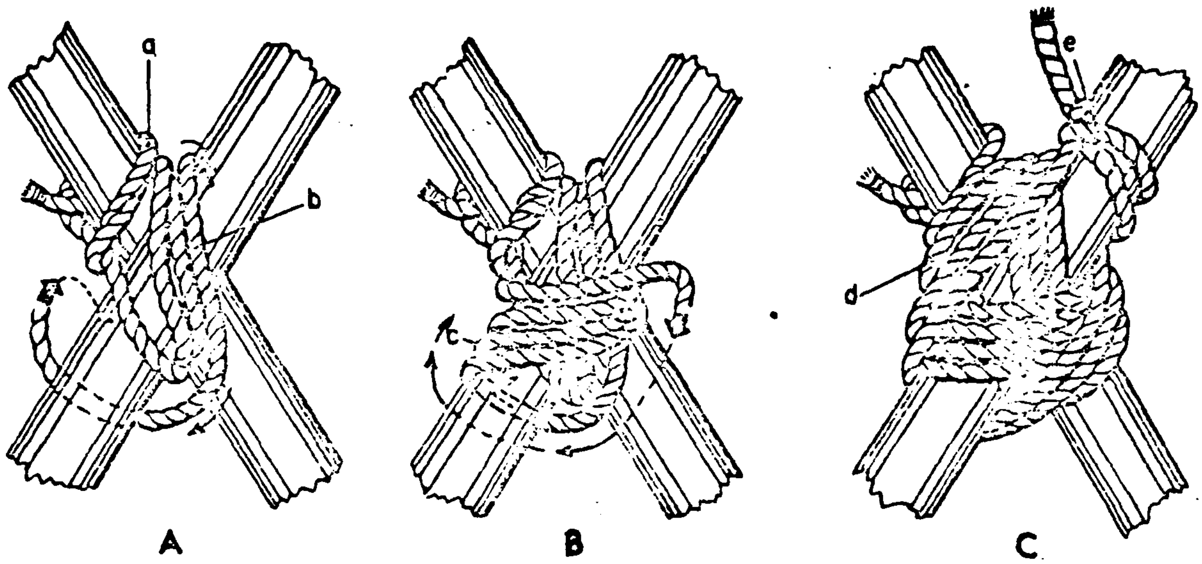
Usually this lashing is used to hold two poles together at right angles. To make this lashing:

1. Start with a clove hitch (a. above) around the standard below the ledger (crosshead) and wrap the long and short ends together (b). Then take the twisted ends up and around both standard and ledger (in the direction of arrow, above close hitch (a).
2. Repeat this circuit 3 or 4 times (b), drawing the rope taut.
3. Take four frapping turns (c) around the whole lashing between the spars (c); draw taut, and finish with a clove hitch (d) on the ledger. (D) shows the square lashing viewed from the back.

Diagonal Lashing

This lashing is used to bind together two poles or spars at an angle other than a right angle, especially where their method of use may cause them to spring apart. To make this lashing:

1. Start with a timber hitch (a); then make four vertical turns (b) and draw taut (A).
2. Make four horizontal turns (c) and draw taut (B).
3. Put four frapping turns (d) over the lashing between the spars, draw taut, and finish with a clove hitch (e) (C),



Round Lashing

This lashing is used to bind two poles together, as in forming sheer-legs (A-frame). To make this lashing:

1. Start with a clove hitch on one pole. (If forming sheerlegs, a spacer block must be used).
2. Continue with six close turns around both poles traveling upward (A).
3. Make four frapping turns securing the lashing with a clove hitch on the opposite pole and at the bottom of the lashing (B).

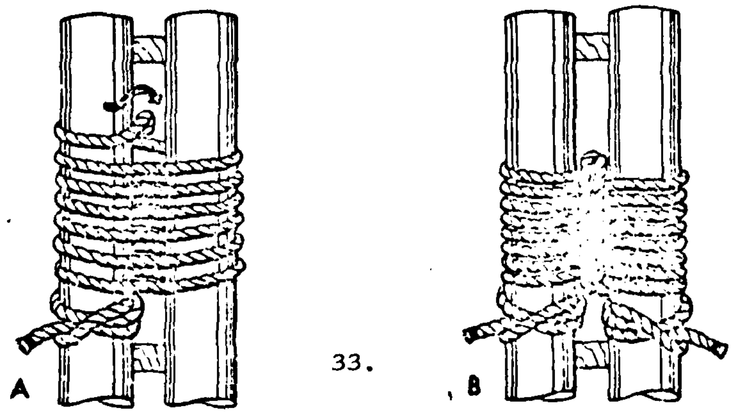
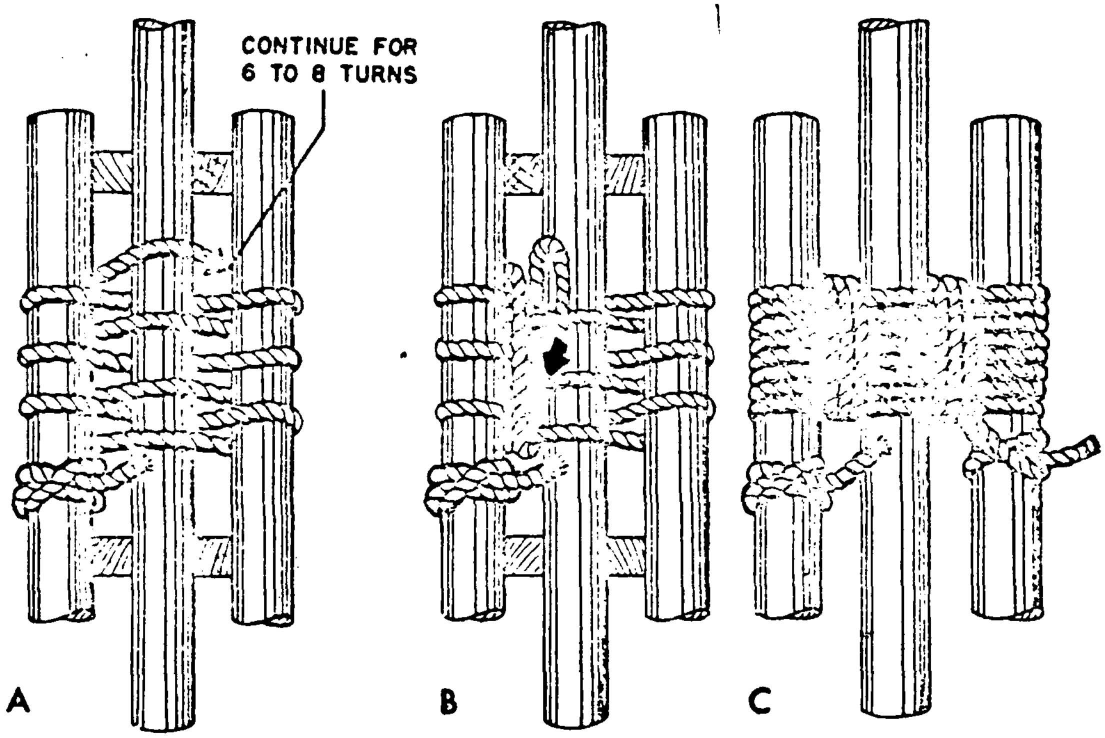


Figure-Eight Lashing

This lashing is used to bind three parallel poles together, as in forming a tripod. To make this lashing:

1. Place three poles parallel on the ground. (If lashing a tripod, spacer blocks must be used and the center pole reversed as illustrated.) Start with a clove hitch on the middle pole, and under and around the third pole.



SLINGS

In order to raise an object a sling may be necessary. The sling is independent of the raising rope or cable in order to add versatility to the system,and so if the sling is destroyed, only a small portion of the system must be replaced. Although slings may be made from a number of materials in an emergency, a standard sling should be adopted in pre-planning and utilized whenever possible. Slings should be made from 1/2 inch diameter material or larger. Smaller sizes are not generally recommended for slings because of the serious effect of relatively minor surface damage and the susceptibility of small ropes to mishandle and overload.

Slings of natural fiber, sisal or manila lend themselves to splices and end attachment more readily than synthetic fibers. Proper thimbles should be used whenever possible to protect the inside

of eye splices. End attachment should not have sharp edges, projections, etc., which might injure the fiber rope. All splices should be made in accordance with the rope manufacturer's recommendations. For manila rope, eye splices should contain at least three full tucks, and short splices should contain at least six full tucks.

Safe Operating Practices

1. Determine weight of load and select sling with corresponding or greater rated load capacity.

2. Use sling long enough to provide the largest practicable angle between the rope and the horizontal.

3. Never shorten a sling with knots.

4. Do not use a sling with obvious or suspected defects.

5. Attach sling securely to load and to lifting device.

6. Pad all sharp corners in contact with sling.

7. In using a hook, make sure the load point is in the base, not on the tip.

8. Avoid kinks and twists in sling.

9. Keep hands, fingers, and feet from between the rope and the load.

10. Stand clear of the load while it is being lifted.

11. Avoid shock loading.

12. Do not drag sling from under a load resting on it.

13. Protect sling when operating near source of high temperature.

14. Special additional precautions must be observed when working around electrical equipment.

Inspection of Fiber Slings in Service

Slings in service should be inspected periodically and should be retired from service if any of the following defects are present:

- Abnormal wear by visual inspection.
- Powdered fiber between strands.
- Broken or cut fibers.
- Variations in size or roundness of strands.
- Discoloration or rotting.
- Distortion of associated hardware.

ANCHOR SYSTEMS

Many technical rescues and/or evacuations will require the use of an anchor system. The rope, block and tackle, etc. will need to be secured to some type object. Very often these anchors are simple, utilizing such common and convenient objects as telephone poles, trees, boulders, car bumpers, fire truck frames and a variety of other strong and well-secured points or objects. (See following illustrations.) At other times these systems may involve relatively weak and/or uncommon objects such as several small bushes, roof structures such as television antennas, air conditioning units, and similar points. Anchors need to be completely safe, but at the same time, as simple as conditions will permit. If an error is to be made in selection of anchor sites it should be done on the conservative side; i.e., tie to more bushes rather than less. The loadings in heavy duty rescue work are generally predictable but may be large -- 1,000 pounds is not unusual.

Indigenous Anchors

The anchor may be so simple as a very sturdy live tree. Some anchors are very obvious and lend themselves to this function quite readily; i.e., a large boulder, telephone pole (be alert to break-away poles), a large chimney complex, fire escape ladder, etc. Fire hydrants should not be used as anchor points; they may be of the break-away type or may be needed for their intended use. Two or three turns around these objects and a knot may be all that is necessary to provide a more than adequate anchor point. Very often, more than one turn should be taken around an object to assist the rope from being pulled up or down along the anchor. If this is not a problem due to the structure design, then possibly a large loop with a bowline and half hitch will be sufficient to the anchoring. The following precautions should be taken:

- The rope must not slip off when pulled in the direction of the evacuation. Extra slings or carabiners may be required to hold the anchor in place.
- There must be no sharp corners which could cut the rope. Such corners can be padded with spare clothing, turnout gear, packs and other objects.
- The lengths of all turns should be equalized to distribute the load between the loops.
- The angle between strands at the brake system attachment point should be less than 90° to prevent larger loading on the anchor than in the evacuation rope.

Deadman and Picket Anchors

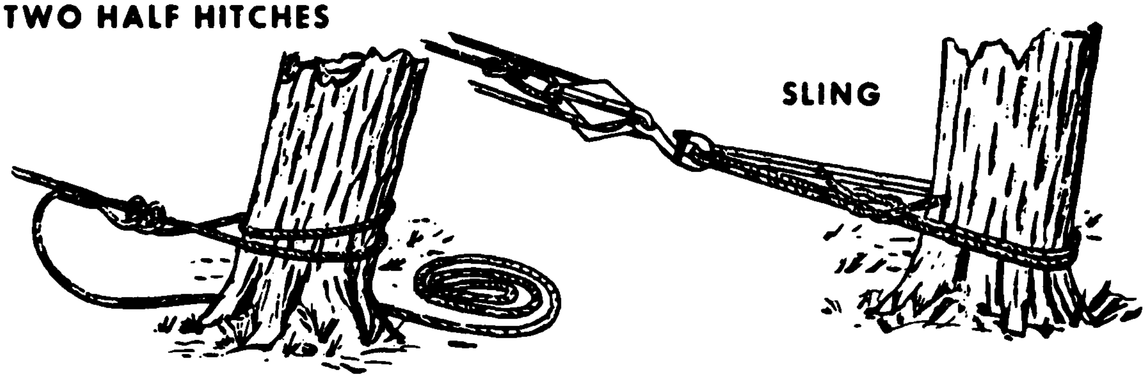
Occasionally a rescue anchor must be set up in a location devoid of natural or suitable indigenous anchors. In a rural setting this may be frequent. In an urban setting this may be encountered during a wide scale catastrophe where most standing objects are structurally compromised or where heavy duty fire and rescue apparatus are unable

to get close to the rescue site. In this event, an anchor may be set up in the dirt or rubble. The class anchor for this is the deadman anchor. This may consist of a log, garbage can top, pipe or other suitable object, buried in two or three feet of dirt. The log or object is placed and buried in a trench cut at right angles to the direction of pull. In a scene with pavement all around, the underground burial may be replaced by above-ground burial in rubble.

The anchor rope is tied around this object. This anchor rope goes in a small slot cut in the ground from the deadman to a few feet in front of it. If it is desired to prevent the rope from cutting deeper into the ground, a small log or other padding may be placed under the rope where it comes to the surface. It the event the dirt is somewhat loose such as in sand, volcanic soil, or snow, stakes can be driven into the ground between the pull force and the deadman. A large log may be hard to find which may again mean any object may be utilized as a deadman. If the rescuer feels the single deadman is not sufficiently strong to take the force, possibly a series of several small deadman anchors could be utilized instead. As with all aspects of rescue work, it is paramount that the rescuer be able to IMPROVISE.

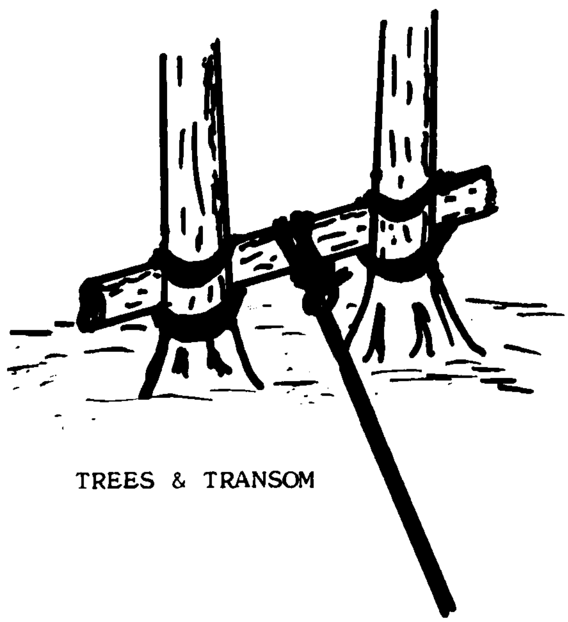
Pickets may be faster and easier to set up than a deadman system if the ground is not rocky and the pickets or stakes are available. The pickets or stakes are merely driven into the ground at an angle of 20 to 45 degrees. The stakes (seldom is one stake strong enough) will be secured to each other so the force of pull is done on a series of tandem stakes. These stakes need not be too sizable if the system is done in numbers. For extra security, two or more sets of pickets could be used together with an equalizing anchor system. Pickets should be of sound material such as metal, snowstakes, beams; and should be of appropriate length for the surface they are penetra ing, as well as sufficient diameter. When using hardwood, allow three inches, and for softwood more than 4 inches. The pickets should be driven into the ground about two-thirds length and never more than a few feet apart.

Another method of setting up a quick deadman without employing trenching tools might be the application of a strong crossbeam across a window of suitable size, a manhole, behind two telephone poles, or uprights near to each other, or other natural or manmade openings.



GUY LINE WITHOUT BLOCK

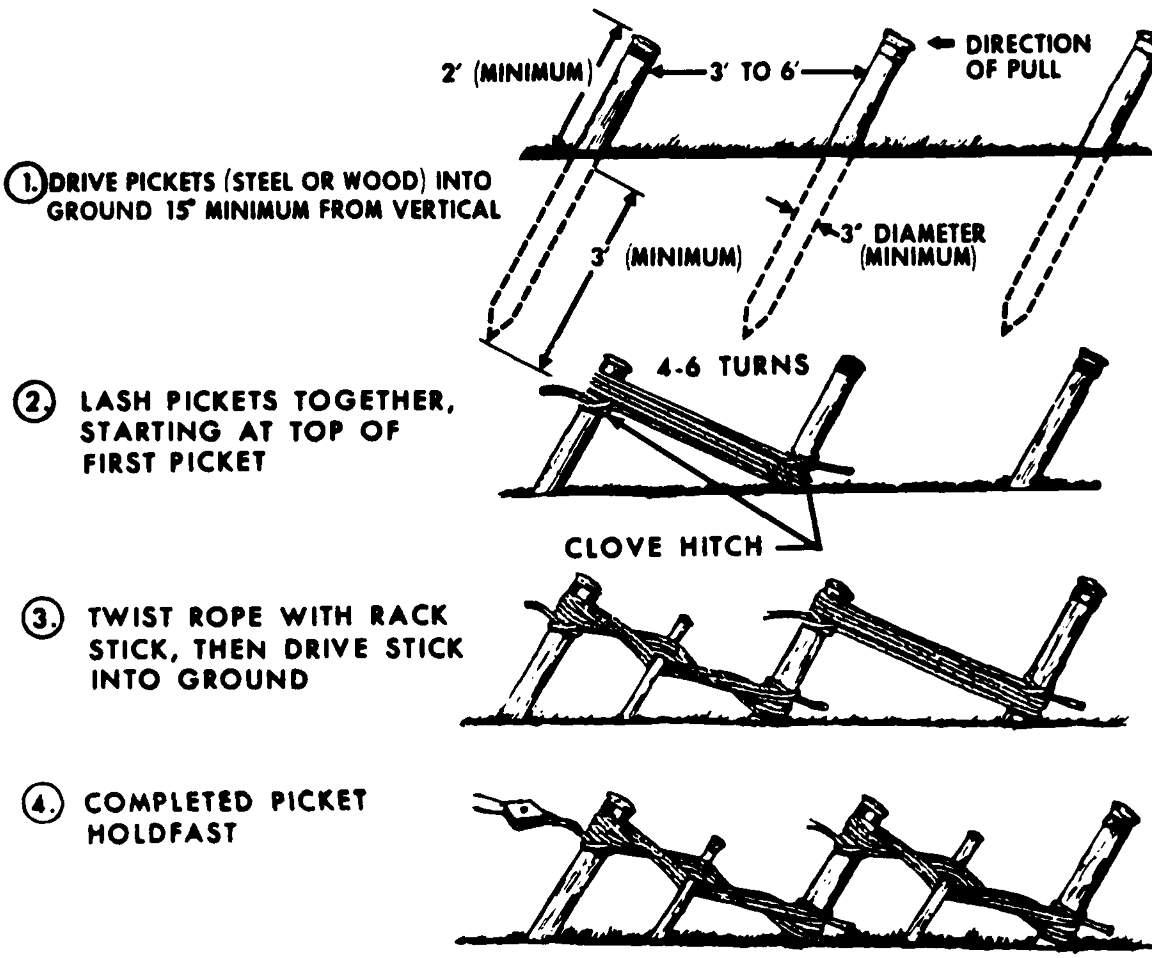
GUY LINE WITH BLOCK

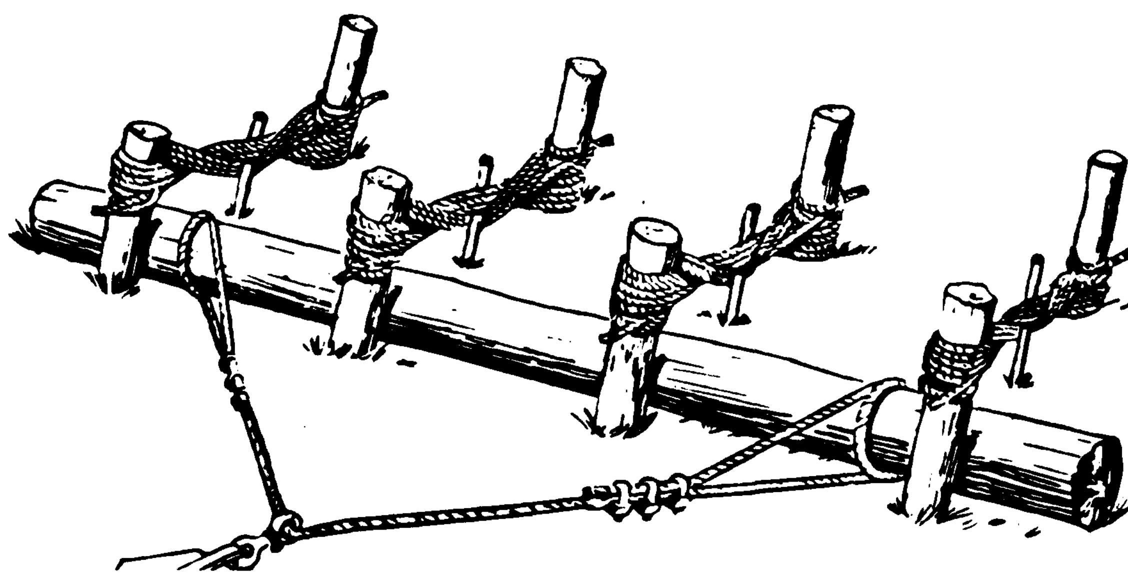


TREES & TRANSOM

ROCK

PICKET SYSTEM ANCHORS





Picket & Transom System

Holding Power of Deadmen in Ordinary Earth

Mean depth of anchorage in feet	Inclination of pull (vertical to horizontal) and safe resistance in pounds per square foot of projected area of deadmen				
	Vertical	1:1(45°)	1:2(26.5°)	1:3(18.5°)	1:4(14°)
3	600	950	1,300	1,450	1,500
4	1,050	1,750	2,200	2,600	2,700
5	1,700	2,800	3,600	4,000	4,100
6	2,400	3,800	5,100	5,800	6,000
7	3,200	5,100	7,000	8,000	8,400

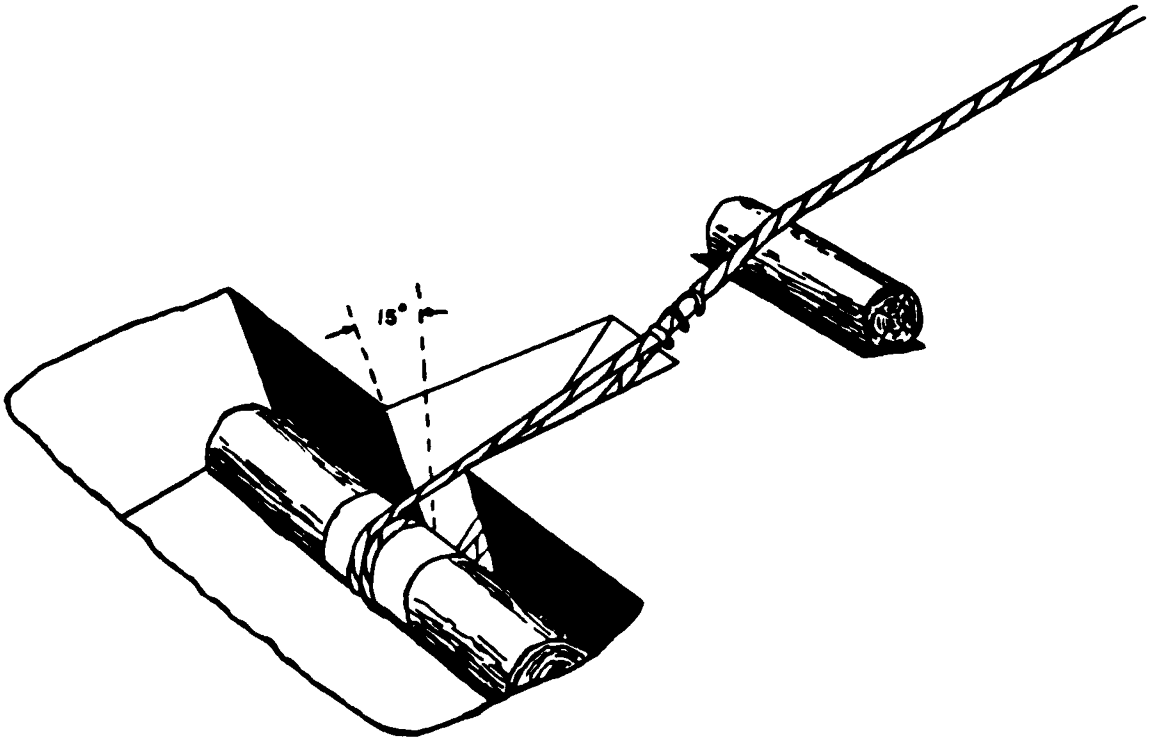


Figure 4-13. Log deadman.

(3) *Deadman formulas.*

(*a*) $BA_{r} = \frac{BS}{HP}$

(*b*) $EL = \frac{BA_{r}}{D}$

(*c*) $TL = EL + WST$

(*d*) $VD = MD + \frac{D}{2}$

(*e*) $HD = \frac{VD}{SR}$

(4) *Sample problem.*

Given:

(*a*) 1 in. dia. 6 x 19 improved plow steel rope

(*b*) Mean depth (MD) = 7 ft

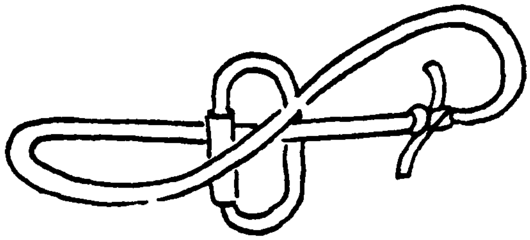
(*c*) Slope ration (SR) = 1:3

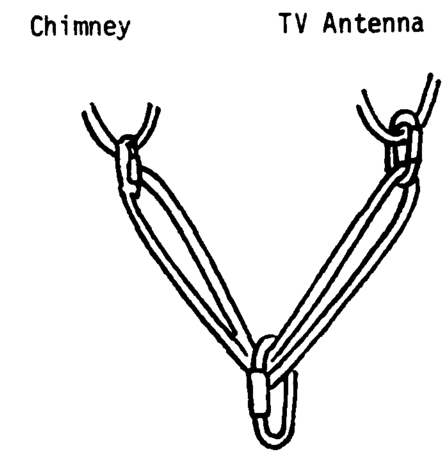
(*d*) Width of sloping trench (WST) = 2 ft

REQUIREMENT I: Determine the length and thickness of a rectangular timber deadman if the height of face available is 18 inches (1½ ft).

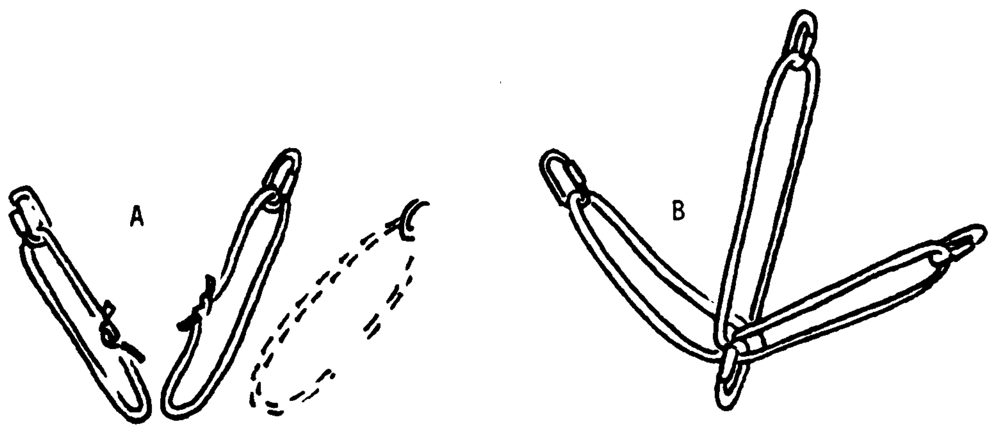
Self-Equalizing Anchor Systems

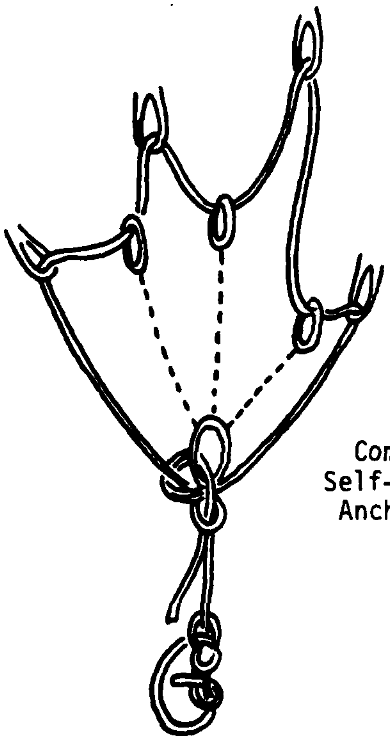
When a single anchor is not strong enough to give a reasonable margin of safety for an evacuation anchor, several smaller points may have to be secured to form a system known as a self-equalizing anchor. This system distributes the weight between the various anchor points; and if any one anchor fails, the weight is automatically redistributed among the remaining anchor points. This system places an equal load on each point; simply passing the rope from one anchor to the next in a large loop and attaching the brakes to this loop will not work. This is not a self-equalizing system. Be cautious also of using several short loops independent of each other as shown in the following illustrations. If done properly, the system is very adequate; but the danger lies in allowing too much slack in one of the loops, causing the other anchor to fail due to the slack placing undue stress on the remaining anchor. This slack and the resulting force may do damage to the rope or, even worse, may pull the anchor out. When employing an anchor system in any aspect of rescue work, it is imperative the rescuer ask himself, "what happens if.........?" This philosophy will often mean the difference between success and failure.





A simple self-equalizing anchor using several small loops of webbing or rope.





A Complex Self-equalizing Anchor System

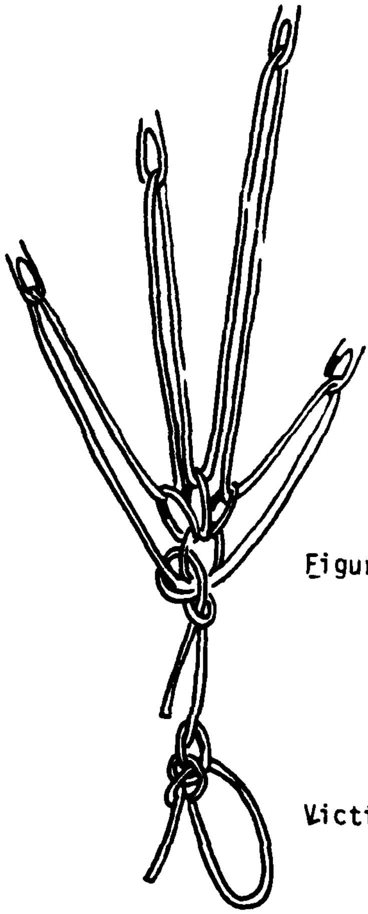


Figure of Eight Knot

Victim

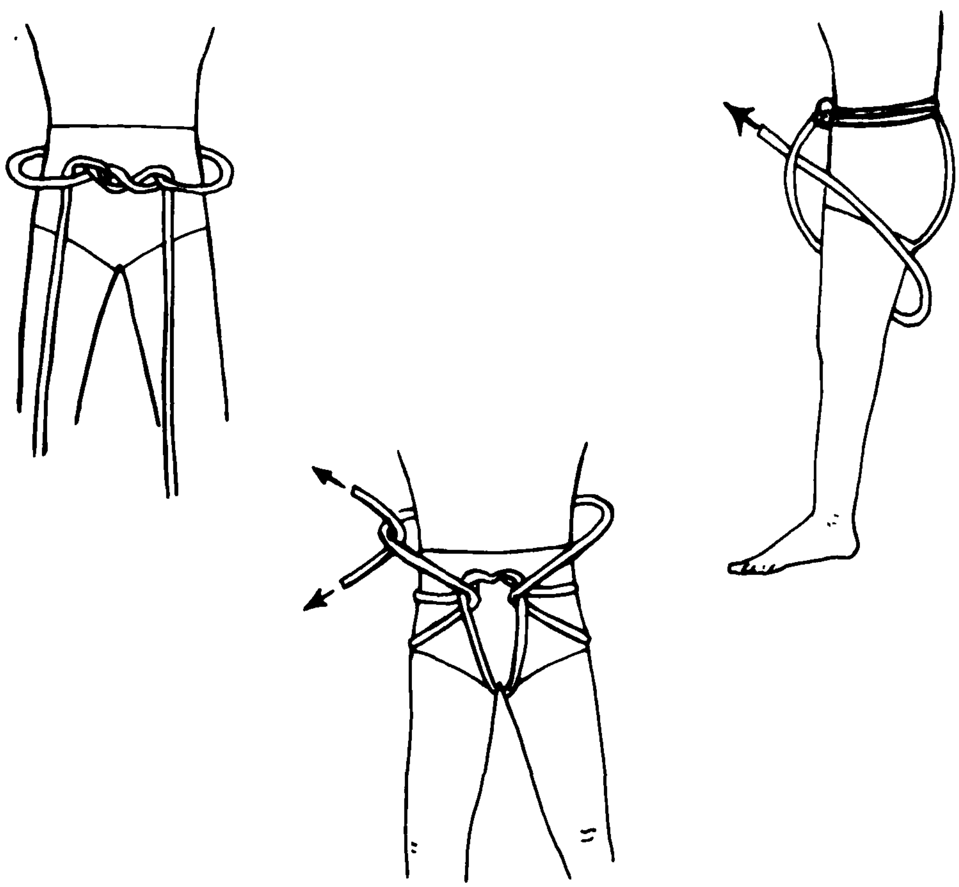
For use on several anchor points or if only weak anchor points are available.

<u>IMPROVISED SAFETY HARNESSES</u>

Many times rescuers or victim will need the facilities of a safety harness yet not have one available. However, to improvise a safe, reliable harness is not difficult. The Swiss Seat Harness is one of the safest and strongest available. Its advantages are: it is self-adjusting, distributes force evenly in line with the body, provides pelvic support, and holds the user in an upright position while not riding up to impinge on the chest and diaphragm.

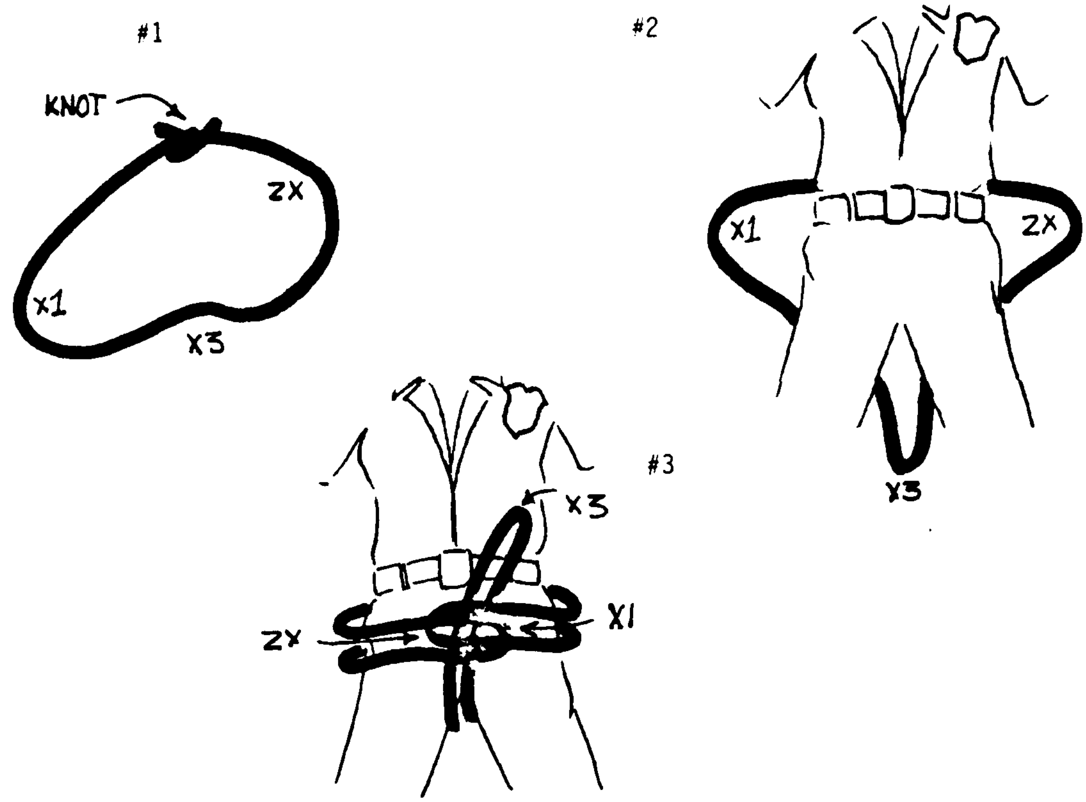
To tie the Swiss Seat, obtain a 12-15 foot length of rope or synthetic webbing not less than 3/8 inch (9 mm) diameter, or webbing of not less than one inch (26 mm) width. After selecting a proper sling material, the first step is to tie the sling at midpoint around the waist and secure snugly with an overhand knot.

The two resulting free ends are now passed between the legs, front to back. Continue around so each leg has a half hitch on it and the sling ends are again hanging between the legs. These ends are then passed around the waist and secured with a square knot backed up with a half hitch. The attaching point or anchor point on the harness is at the overhand knot. The Swiss Seat can also be tied on the fire fighter's pompier belt to provide additional strength, comfort, and security.



An alternative to the Swiss seat is the modified diaper sling. While not as safe as the Swiss Seat, it can rapidly be put on an unconscious, precariously positioned victim. To construct a diaper sling, select the identical material (length, size) as you would for the Swiss seat. Tie it into a continuous loop, then pass it around the back and grasp the sling at three points -- left at waist, right at waist, between the legs to create the diaper. Now pass the middle or crotch loop from between the legs through each waist loop.

DIAPER SLING



LITTER RIGGING UTILIZING BOWLINE ON A COIL KNOT

This rigging can be accomplished quickly using short peices of line. In an emergency or when you do not wish to cut a good rope into pieces, a single strant can be employed. The greatest virtue, other than simplicity, for using the Bowline on a Coil is that the loops are adjustable. In the event the litter needs to be tilted while going over a roof lip, etc., the loops can be lengthened or shortened which then tilts the litter in the desired manner. This would be particularly important when administering certain first aid maneuvers such as airway maintenance.

The knot can be tied directly to the rails as shown in the illustration below (Figure A and B) or the rope can be tied into a carabiner on either side of the rails. If carabiners are available this would be the preferred method. This is because the carabiner could be unhooked from the stretcher without jeopardizing the rigging or know. This is not true when the rope is tied directly onto the railing. Another danger when the knot is tied directly around the railing is the abrasion factor. There will be more tendency for abrasion when the rope is looped around the railing rather than looped through a carabiner. It is also prudent to construct a belay for the victim on hazardous situations. NOTE: Rig short if litter is to be winched by a helicopter.

FIGURE A

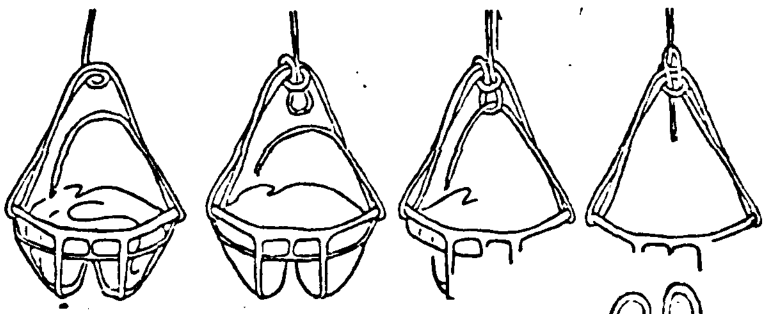


FIGURE B

Air Maintenance

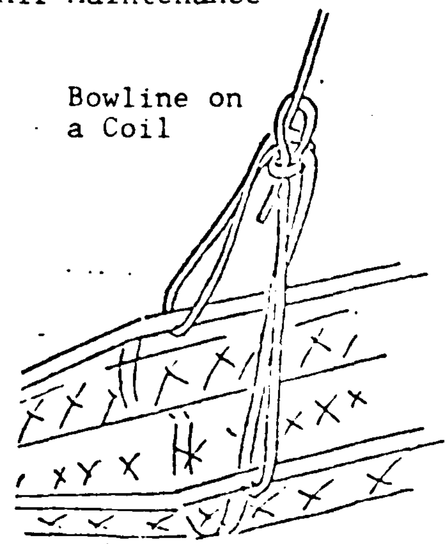
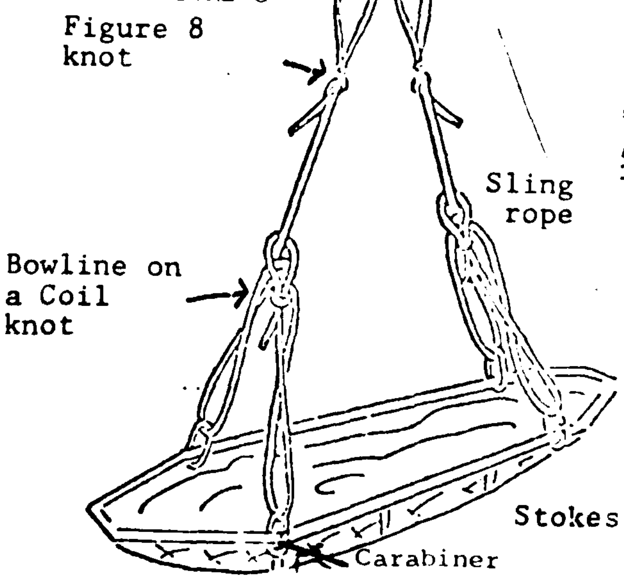


FIGURE C

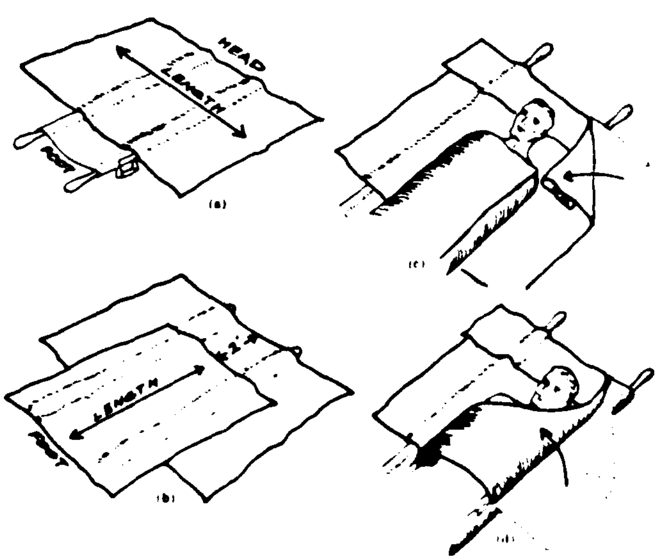


LITTER LASHING - LASHING AN ARMY LITTER (STRETCHER)

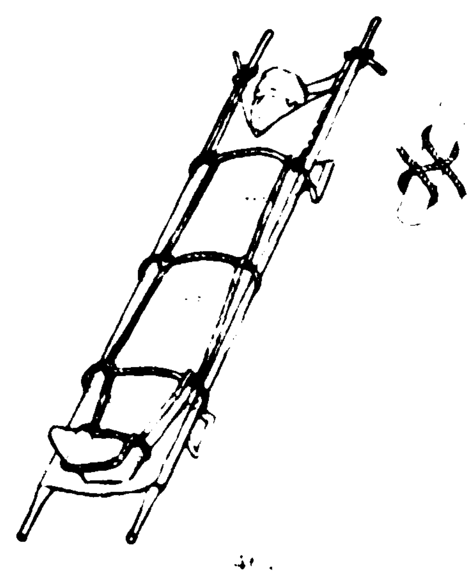
One of the most common stretchers still being utilized by rescue and fire personnel throughout the country is the basic Army litter. The canvas and wooden stretcher has limitations in strength when used for raising and lowering operations, but does have the virtue of compactness when folded and universal accessability. In the event the victim of an injury needs to be secured to this litter for transport, it should be done carefully as follows, and illustrated below:

1. Blanket the stretcher (a).
2. Using approximately 40-50 feet of line, start the lashing (b) with a securing hitch on the handle of the stretcher at the head end. A timber hitch or clove hitch would be ideal for this purpose.
3. Make three half hitches around the victim and the litter in the following locations:
   a. Halfway between the elbow and shoulder;
   b. At the wrists or the waist area;
   c. Between the knees and the thighs.
4. Take a half hitch around the ankles and pass the line around the casualty's feet across the instep.
5. Proceed toward the head on the opposite side that you came down and pass the line around the victim at each of the four half hitch areas mentioned above.
6. Finish with a securing hitch on the handle at the head of the victim. Be sure to secure this hitch with a safety knot or hitch.
7. If there is any remaining rope, remove it from the area by either securing under the victim or following the lashing back down for a safety effect.
8. This system may loosen a little as the transport takes place, so it is important to remove as much slack as possible while securing the litter.

A. *Stretcher Blanketing*



B *Stretcher Lashing*



To avoid collapsing the stretcher at the brace area, the braces will need to be tied to the handles at either end of the litter by a stout line of some sort. The lashing described above must be done with the victim's injuries in mind. Obviously if the injuries are in the chest area, the lashing at this point will have to be modified to some degree.

LASHING A STOKES LITTER

Another very common stretcher in use by rescue agencies is the Stokes Basket Litter. The basic design is either steel or alloy frame with wire mesh between the bars. Some agencies have modified this design by employing canvas instead of the wire mesh. Most Stokes baskets are one piece, although many agencies have modified this by making them into either two or three-piece "breakdown" or telescoping designs. This modification may jeopardize the strength a little.

The steps for securing or lashing an injured person to this litter are:

1. Using approximately 20-30 feet of line (either webbing or rope), secure one end on the railing near the neck region of the stretcher. The basket is built so this knot will be in between two vertical supports and will keep the knot from slipping down along the body more than an inch or two.
2. Crisscross this line down the length of the stretcher with about one foot between the points of securing. At least four crossings should be made although more may be employed. When the crossing has been made near the calfs of the leg, pass the rope under the insteps of the feet. This will keep the body from slipping down when the stretcher is in a vertical position.
3. Work back up the frame of the stretcher. Periodically it is good to secure the rope by a half hitch on the frame.
4. When near the neck region of the frame, tie the line off with a securing knot. Be careful of allowing too much slack into the system. As the stretcher is being moved, the line will tend to slacken up.
5. In the event of several lines, the lines may be tied to each other or just affixed to the basket as needed.

PULLEY SYSTEMS

Pulley systems are a very versatile group of tools which employ rope, cable, or chain, operated by a mechanical advantage system with pulleys. In addition to hoisting, these tools can be set up to pull as well. Applications of pulley systems are as numerous as there are situations, and as versatile as the creativity of the men who utilize them.

Some key uses of pulley systems include:

- Lift/lower debris.
- Provide tension adjustment on telpher lines.
- Lift/lower men and equipment.
- Pull doors or structural members in vehicle extraction.
- Provide tension to stabilize objects/vehicles.
- Move vehicles.
- Power levers for prying.
- Power other pulley systems.
- Move, or brace structural components or furnishings.
- Provide inertia or impetus for other power systems.

Pulley systems include any combination of winches, pulleys, blocks, or come-alongs utilizing chain, cable, or line to develop a mechanical advantage.

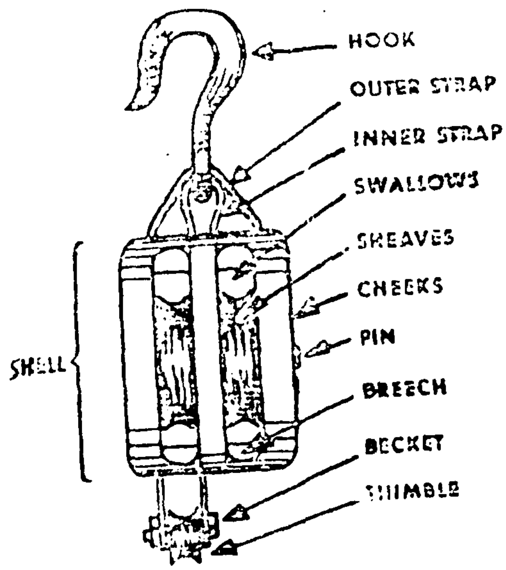
BLOCK AND TACKLE

A lifting device used to raise or move heavy weights, beams, sections of floors, and heavy timber, is the block and tackle. Like levers and jacks, this device provides a mechanical advantage, enabling rescue workers to overcome otherwise immovable obstructions. Single, double, and triple sheave blocks, as well as snatch blocks, will be used, depending on the job to be done. More recently, a new style of pulley called a rescue pulley has been developed. It is extremely strong, lightweight, self-locking, and has the advantage of being able to be attached or rigged to line under tension. A block is composed of a frame made either of wood or metal, and a wheel or sheave, usually made of steel or hardwood.

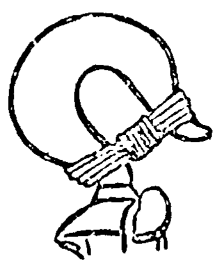
Following is standard block and tackle terminology:

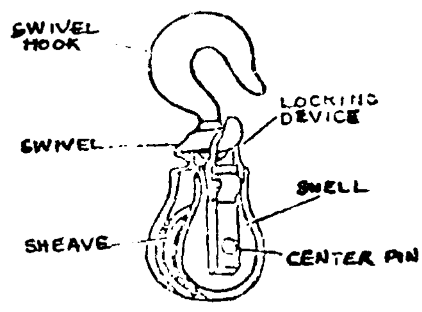
- Block - A grooved pulley or sheave in a frame or shell provided with a hook or strap by which it may be attached to another object.
- Tackle - An assemblage of ropes and pulleys arranged for hoisting or pulling.
- Pulley or Sheave - A grooved wheel held in the frame over which ropes must pass.
- Snatch Block - A single block with an opening or gate on one side through which a rope can be inserted or "snatched" into the sheave without threading the end through.
- Frame or Shell - The part of the block which holds the sheave, and to which the strap, hook, or ring is attached.
- Strap - The part to which a hook is attached.
- Standing Block - The block fastened to the support from which the load is being moved when more than one block is necessary.
- Running Block.- The block attached to the object to be moved when more than one block is necessary.
- Overhauling the Blocks - Process of separating two blocks a desired distance (at least the distance the load is to be moved) before attaching the running block to the load.

- Running in the Blocks - The process of bringing the blocks closer together in a lifting or moving operation.
- Chock-a-Block - When two blocks have been run in as far as possible.
- Becket or Ring - Metal ring fastened to block for attaching rope or chain.
- Standing End of Tackle - End of rope fixed to the block at the becket.
- Running End of Tackle - End of rope on which the pull is exerted.
- Reeving the Tackle - Process of passing rope over sheaves of a block in proper order.
- Mausing of Hook - Cord or marline tied across jaws of hook to prevent rope or sling from jumping out.
- Twisting of the Tackle - A motion of the tackle during pulling usually caused by a peculiar lay in the rope.
- Returns - Moving sections of rope between blocks.
- Power Gain, or Mechanical Advantage - Increase in lifting or moving capacity gained by using the block and tackle.
- Heave - Signal for members of the team to exert pull on rope; also act of pulling.
- Gain - Distance the weight is lifted or moved.

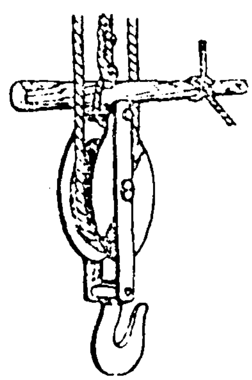


—Block or pulley in a shell.


—Mousing of hook.



—Snatch block.


—Method of preventing tackle from twisting.

GAIN IN POWER

Conventional blocks are named for the number of sheaves they contain and also the number of sheaves somewhat determines power gain. To rapidly and accurately determine the true gain, one can conduct a simple test. Note the running line where it exists the final sheave, pull on the line and observe how far the lower or lifting block rises. Comparing this net lift to the amount of line needed to be pulled will indicate the mechanical advantage of the system. (Example: 5 feet of line pulled from the upper block lifts lower block one foot=5 or a theoretical M.A. of 5:1.)

The mechanical advantage indicated on any pulley system is theoretical only. True mechanical advantage is figured only after subtracting the mechanical force needed to turn the sheave on its axle. Theoretically, a pulley should transmit 100% of the force which travels across it. Practically, we know that we only get 70-80% efficiency on all but ball bearing sheaves. Thus, a 6:1 system has a net or practical mechanical advantage of about 4.2 or 4.8:1.

If the reeving twists and provides further friction, we may end up with only a 3:1 practical mechanical advantage. If we are counting on lifting a weight of 6,000# with a 6:1 system, it is critical we understand it may take much more lifting force to accomplish the lift than the pulley system indicates theoretically. Therefore, with all factors considered, the basic rule for setting up pulley systems should be: set up a system which will be 100% more powerful than the available power indicated.

Example:

Load 5,000#

Theoretical M.A.	10:1 = Power Theoretical = 500#	10	Sheaves
	6:1 = Power Practical = 830#	x.7	Pulley Effciency
		7.0	
		-1.0	Reeving Twists

Thus, we thought we could lift 5,000# with a 10:1 system by generating only 500#. Using the above rule, we provided a lift power of 1,000# and find that it actually takes 830# to make the system work, giving us a 170# margin. If we had a maximum capacity for available power of only 600#, then we must either increase the power or add pulley sheaves to the setup and recalculate. Of equal importance is the selection of the proper rope or line. The guiding rule is that the rope will have exerted upon it a force or weight equal to the force required to accomplish the lift. So in the foregoing problem, we must have a line of at least 830# strength to accomplish our job, as indicated from the practical mechanical advantage.

Finally, we must understand that with a theoretical 10:1 system we will have to use 110 feet of rope to lift 10 feet. Example: 10:1+1 = 11 x 10 feet the desired life = 110 feet of (TMA) rope or cable when reeved conventionally.

PRECAUTIONS

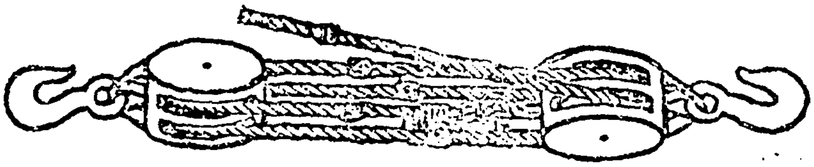
In using block and tackle, the following safety precautions should be observed:

- Always check blocks and sheaves to ensure they are in good condition. Keep them clean and the bushings well greased.
- Be sure the tackle used is the right size rope for the block.
- Be sure the tackle used is the right size rope for the weight to be lifted.
- When pulling on a line, everyone should exert a steady pull simultaneously. Only the leader in charge should give orders. On the sheave, all should pull together and hold onto the gain.
- When lifting a load, be sure the support holding the top block will hold the load as well as the pull.
- To prevent wear on the rope, be sure to pull in a direct line with the sheaves. Whenever possible, the pull should be downhill.
- All those pulling should stand so they will not be in danger if the tackle or support should fail.
- Easing off on a suspended weight should be done gradually and without jerking.
- When several men are pulling on a line, they should work alternately on opposite sides of the rope to keep it in a straight line.
- Never use wire rope on a block with sheaves designed for manila rope, and vice versa.
- Attempt to have a prusik brake installed on the system for safety.
- When blocks get closer than 2-3 feet to each other, most <u>all</u> mechanical advantage or gain is neutralized.

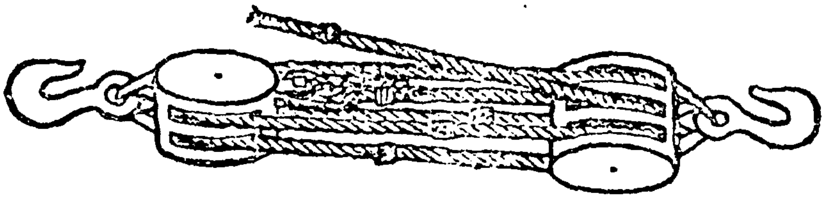
OTHER LIFTING DEVICES

Chain hoists also will be useful. These may be found on wreckers or tow cars. Generally, they are used for raising or lowering weights. They depend on the gear ratio of the hoist mechanism for the ratio of the weight lifted to the required pull on the lifting chain. Chain hoists may be difficult to operate at night and are not practical for use in a horizontal pull.

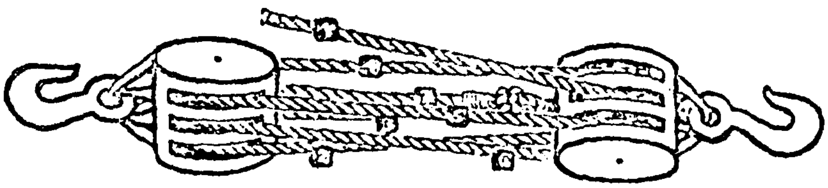
Gear lifting tackle, employing a gear train with a handle and ratchet, is valuable in rescue work. It can be used on both vertical and horizontal pulls, and does not have lengths of loose chain to become entangled. It may be set up faster than block and tackle and requires less space to operate.



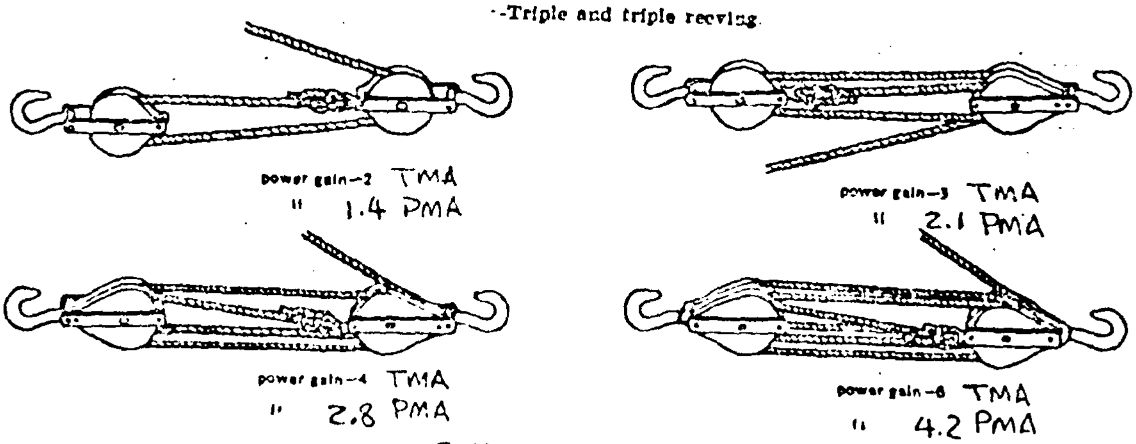
—Double and double reeving.



—Triple and double reeving.



--Triple and triple reeving.



-Tackle combinations and power gains.

T M A - Theoritical Mechanical Advantage

P M A - Practical Mechanical Advantage

PRUSIK SAFETY ON PULLEY SYSTEMS

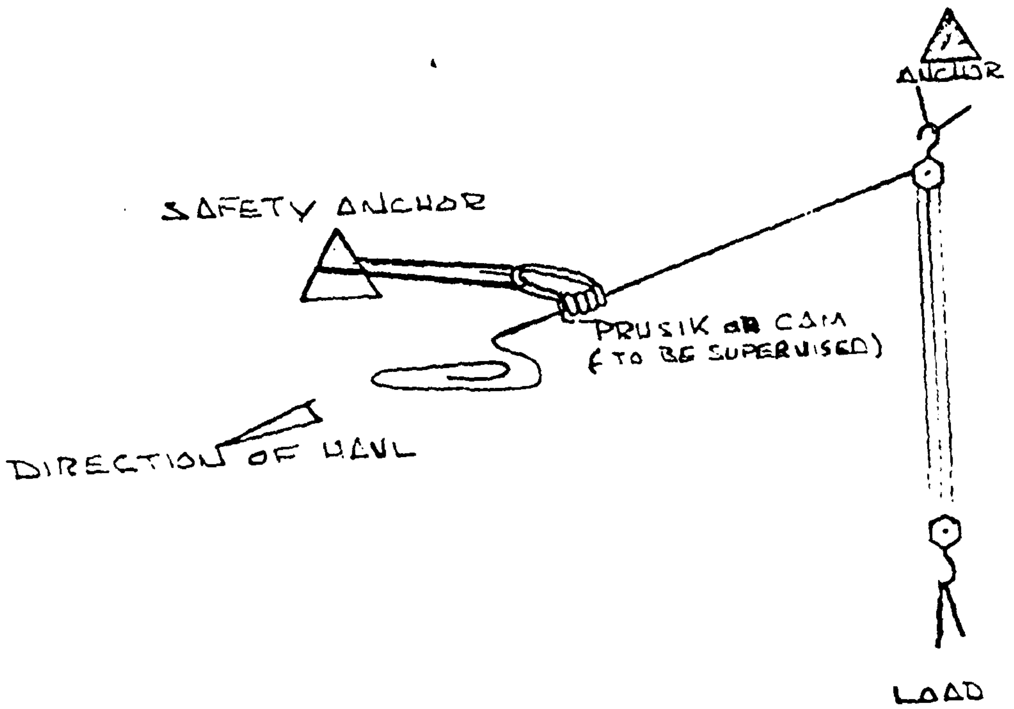
Most manual powered pulley systems have one major weakness: the humans supplying the required force can become exhausted or may lose their grip and all effort may be lost in a slight mishap.

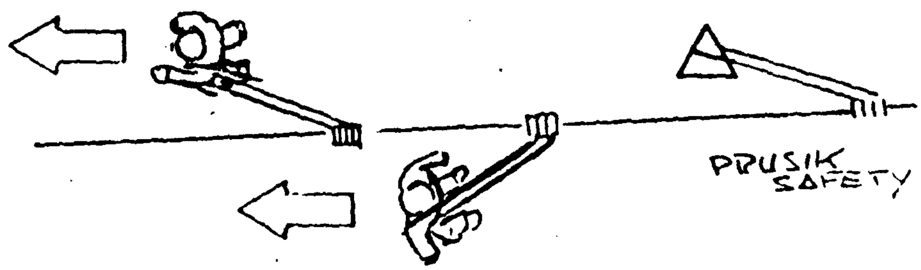
Ideally, some mechanism must be inserted on the haul line to act as a safety or brake device for rest periods of temporary anchoring of a line. To accomplish this goal, the prusik knot (a highly efficient friction knot) can be used with excellent results for loads up to 1,500# (or requiring, through mechanical advantage, a net operating force of 1,500#) at which point a prusik begins to slip slightly.

For maximum grip, the rope used to tie the prusik knot should be no greater than 3/4 the diameter of the line upon which it is to be attached. The prusik knot's job in the pulley system is to float along as the haul line is pulled in; then to lock whenever needed, yet unlock and allow rope to continue to pass through it the moment tension is released. This requires that one man should be stationed to be the knot or brake tender. This position is ideally manned by the team leader as he can see the rigging, the workers, and the condition of the load or what is being lifted. Thus, he can lock the system at any point during the operation. For obvious safety reasons, the prusik's anchor should be a separate and independent object.

To aid in the locking and unlocking ability of the knot, it should be tied with three wraps rather than the conventional two, and should not be tied with any highly stretchable type line, since under load it may stretch and jam on itself.

The prusik can also be of use in manual haul systems as an aid to individuals trying to get a grip on small, wet or slippery rope. When locked, it affords an excellent hand-hold or harness attach point which can be relocated when tension is released. In extreme cases, a pair of 3 or 4-wrap prusiks can be used on steel cable or wire rope. However, caution is advised as most cable abraids rope very quickly due to many broken or burred strands.





USE OF PRUSIK'S FOR HAULING GRIPS

CARE AND USE OF BLOCK AND TACKLE

Blocks and sheaves should be inspected for flaws regularly. The bushings should be well-greased. Be sure, however, that grease or oil does not get on the rope. Twisting of the tackle is normal, especially if the rope is layed. The force required to lift a load almost doubles if the rope has one complete twist. Further, there is the danger of a heavy load breaking loose and injuring the workers. The twisting is due to the lay of the rope. Twisting may be avoided by using either braided or kernmantel line. During a lifting or moving operation, the tackle may be prevented from twisting by insertion of a pick handle or crowbar through a knot at the fixed end of the rope, and at right angles to and between the returns. The pick handle can be controlled with a lightweight rope used as a guy and tied to one end of the pick handle by a clove hitch.

REEVING A TACKLE

To "rope-up" or reeve a tackle, lay blocks about three feet apart, hooks out, so one is horizontal and the other vertical.

HOW TO BUILD AND IMPROVE SPECIAL PULLEY SYSTEMS AND WINCHES

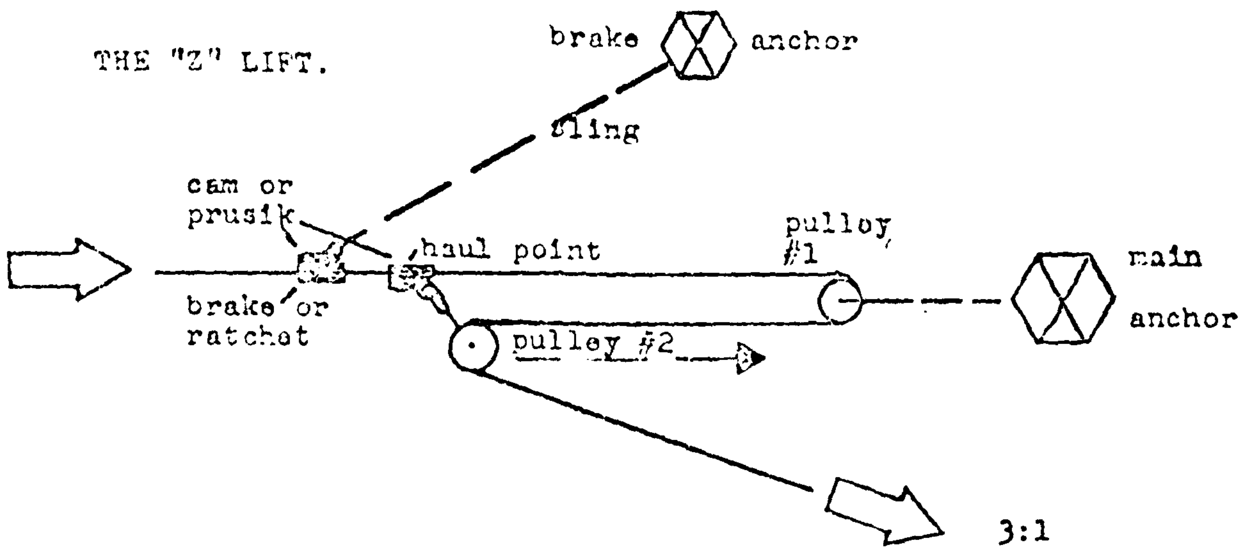
If the number of sheaves and conventional blocks are not sufficient for a given job, then the individual pulley systems can be used in "multiple sequence." It is possible to develop 12:1 systems with only 4 single sheave pulleys or 6:1 with 3 sheaves. In addition, multiplier pulleys do not require continuous reeving and long lengths of line. A 6:1 system may be set up to use as little as 25 feet of line. Thus, to make a 100 foot lift with a multiplier pulley system of 6:1, you will only require 125 feet of rope compared to conventional reeving which would require 700 feet.

The key to developing multiplier systems is to attach pulleys to pull on each other's input side rather than output side. (See illustration of "Z" lift).

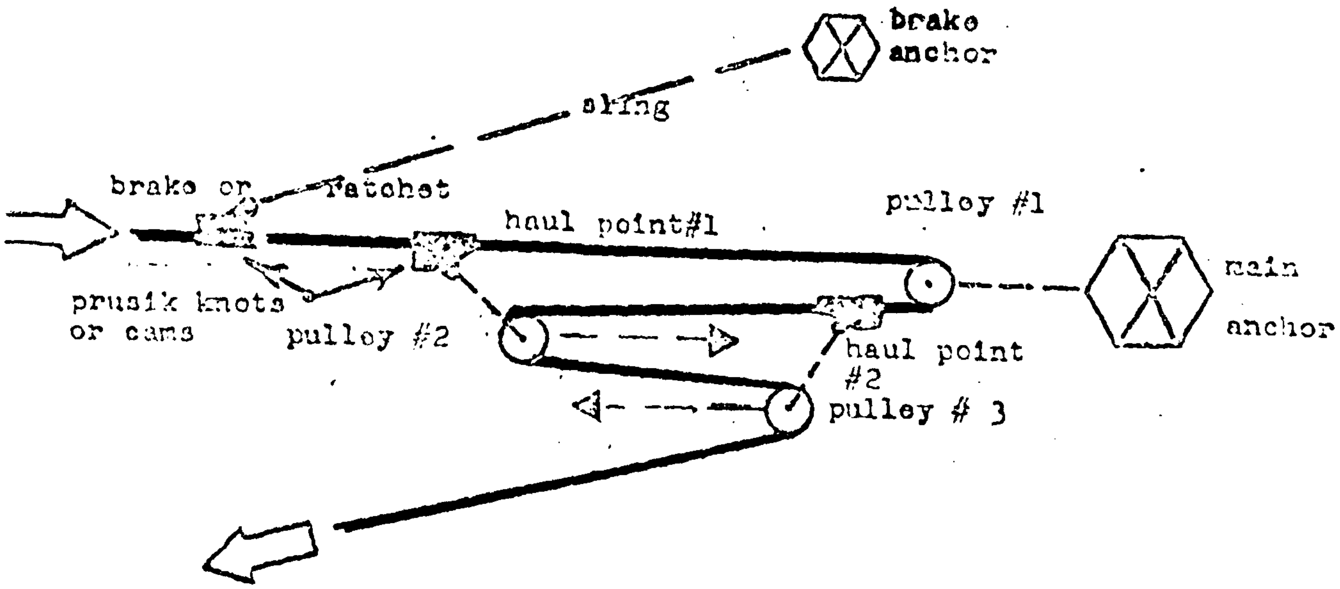
In the above descriptions, it can clearly be seen that all systems have a main brake or safety. Made from a prusik or rope cam, the brake acts as a safety, but more importantly a ratchet point such as found on gear winches, come-alongs, etc. This means that this system will be able to: 1. Pass knots; 2. Be re-reeved to provide more lift in a given cycle of operation; and 3. Add or subtract pulleys from the system.

To obtain a mechanical advantage, rescue pulleys, prusik knots or rope cams and carabiners can be assembled to build extremely efficient lifting systems utilizing a "multiplier pulley" arrangement, 3-to-1 ratio. This system requires 2 pulleys, 2 anchor points, 2 prusiks or cam, 2 slings, 5 carabiners, and 3 personnel.

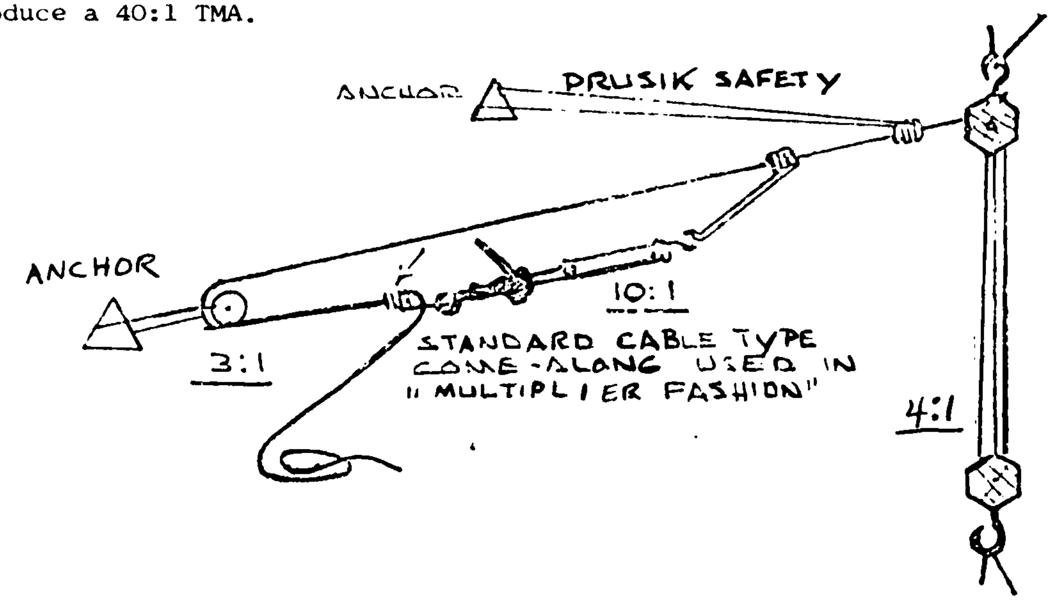
THE "Z" LIFT.



The 6:1 Multiplier System requires 1 haul rope, 3 pulleys, 2 anchors (4 bolts), 3 prusiks or cams, 2 slings, 6 carabiners, and 2 men. Effects of "multiplier" pulley are as follows: Ratio at pulley #1 is 1:1. Ratio at Pulley #2 is 3:1 as it pulls on the input side of Pulley #1 two times rather than one, if it pulled only on the output side. Ratio at Pulley #3 is 6:1 as Pulley #3 acts on Pulley #2 to create a 2:1 ratio, which in turn acts on an existing ratio of 3:1. ----2x3 = 6 ---- By adding another pulley in the same manner we would create a 12:1 system; i.e., 6:1 existing system, multiplied by 2:1 the addition, equals 12:1.



Illustrated below is a "Z" lift being powered by a mechanical cable come-along which powers a conventional block system. This system means that theoretically, a force generated by the come-along would be multiplied 120 times. Without the "Z" lift, the come-along, attached by prusik or cam, acts on the blocks to produce a 40:1 TMA.



WINCHES

In the event heavy objects need to be lifted or moved, injured parties need to be raised or lowered, vehicles freed from sand, etc., a winch may be used. In non-emergency situations most winches described in this manual are illegal to use for raising or lowering humans. Although the power may be there, State and Federal regulations may progibit their use. In an emergency where life is at stake as the result of a major disaster, these laws may not be applicable.

The state of the art of winching is very well refined for industrial and recreational uses. Depending on the type of winch being used, there are limitations to be considered. However, it is imperative the user become familiar with the limitations of those winching devices he may use in an emergency. Some of these limitations are:

- Weight
- Bulk
- Noise
- Power sources
- Anchoring points
- Operators
- Dependability
- Availability
- Maintenance
- Speed

Winches come in many different makes, models, sizes, weights, complexities, etc. Winches basically come in two forms: hand-operated and artificially powered.

HAND-OPERATED WINCHES

The simplest and probably most common winches available to the rescuer and layman are those powered by hand. There are a number of models available from those "come-a-longs" designed to free you from a sand trap, to the hand winches on a boat trailer. In an emergency these winches afford a great deal of assistance in providing a mechanical advantage of up to 50:1. If you have ever seen a basic "fence puller" in action, you will realize this device will be of great assistance in pulling and lifting during times of disaster. Due to the small size of these devices (approximately 3 feet long), they may be utilized in small spaces or where space is at a premium; i.e., caves or small ledges.

Remember, these devices are not made to routinely lift people or lift objects over people, but in an emergency may be pressed into such service. Average weight of the winch is 8 pounds, and it often will be capable of pulling an object up to 35 feet. These devices use cable and can be used with rope as well. There are several "come-a-longs" which are capable of pulling an unlimited amount of rope. The only limiting factor will be the length of the rope. In a high rise raising or lowering, this may be a very useful tool when using a rope of great length. In the event any of these hand devices are used, there is a need to consider a "back-up" for safety. If moving objects where people are not exposed to hazard, the need for a safety may not be necessary. However, if a stretcher is being lowered down an elevator shaft or a heavy object is being raised above someone working, the rescuer must consider a safety line in addition to the hauling line.

ARTIFICIAL POWERED WINCHES

These winches utilize either gasoline or electricity for power sources. They are available in a variety of sizes and strengths, according to primary use. The most common winch is that mounted on the front of four-wheel drive vehicles. The average rating for this type winch is 5,000 to 10,000 pounds, with electrical and power take-off features. The advantage of the smaller, recreational winch is the universatility, the number of operators experienced in its usage, the lighter weight for the same pulling capacity, and its mobility. The advantages of the heavier, industrial-rated winch is its larger load capacity -- up to 50 tons, and the variety of power sources -- electric, gasoline or power take-off/hydraulic.

ELECTRIC POWERED WINCHES

The advantage of an electric winch is its capacity of 750 to 9,000 pounds. Usually battery operated, they will operate when the vehicle is not running, even on steep grades. They are less expensive and easily installed. There is no modification required, they are easy to operate, portable, and can be temporarily mounted elsewhere (i.e., from one vehicle to another).

POWER TAKE OFF WINCH (PTO)

A PTO winch is connected to the mechanical linkage of the vehicle's transmission or transfer case. The advantage of this type winch is they are able to pull greater weights up to 100,000 pounds. They can work longer and retain full power without battery drain. They can be used in conjunction with the vehicle's transmission to increase or decrease line speed as necessary. The PTO can be used to drive other equipment.

WORM GEAR WINCHES

Worm gear winches are the most common gasoline-driven winch available, and are probably the most ideal for hoisting or handling loads on inclined surfaces where there is a tendency for the load to shift. This efficiency is due to the high coefficient or friction in the gear train. When power is not applied, the friction holds the load securely. As worm gear winches "wear in" however, some or all of this self-locking ability will be lost. Thus, if the winch is intended as a hoist or where positive braking is required, winches should be equipped with an electric brake.

These winches are also equipped with a drum clutch for free-spooling. This feature is useful when working over long distances. These winches are most commonly found with motor horsepower ratings from 1/2 to 3 HP, and with lifting capacities from 700 to 6,000 pounds. These capacities are for dead lift, single line loads.

SPUR GEAR WINCHES

Spur gear winches are more efficient than worm gear winches because less power is lost to friction in the gear train. Spur gear winches give more pull per horsepower and higher line speed, but do not have the self-locking capability of the worm gear winches. If load holding ability is required for working with loads not on level ground, the devices can be secured with motor brakes. Spur gear winches are generally available with motor horsepower ratings from 1/2 to 10 HP, with capacities from 600 to 7,000 pounds. Electric motors are also available in single and three phase, 110/230 V and 230/460 V models.

GASOLINE POWERED WINCHES

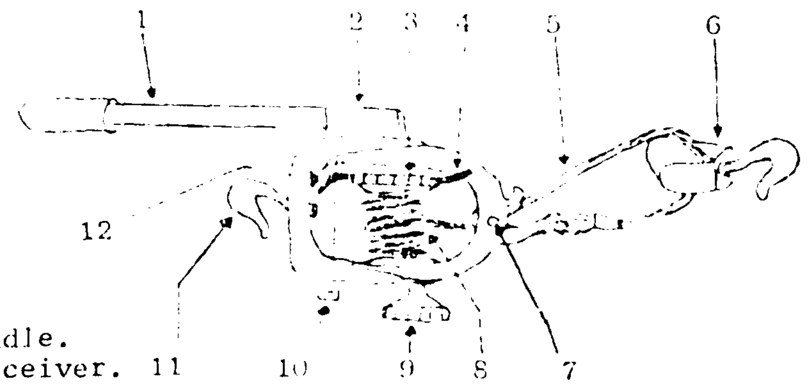
Gasoline winches are used in construction, roofing, and many other areas where a winch is required and no electricity is available. The winches use a transmission-type reversing clutch between the engine and drum to give power when pulling or playout of cable. Direction can be changed under power. A second clutch on the drum shaft allows free-spooling of cable. These winches are available with engine horsepower ratings from 5 to 9 HP for capacities up to 5,000 lbs. As with any gasoline-powered device, caution must be exercised when working in areas of confinement or atmospheres of ignition.

The following chart depicts rolling load capacity of winches rated at dead lift (vertical lift). The figures are approximate, based on ideal conditions. Factors such as friction of the rolling surfaces, uneven or soft ground, mud, dirt, etc., will effectively increase the load weight on the winch.

DEAD LIFT CAPACITY	PULLING CAPACITY - ROLLING LOAD ON GRADE				
	GRADE % 70%	50%	30%	20%	10%
	DEGREE 35°	26°	17°	11°	6°
750 lbs.	1000	1350	2250	3375	6750
1,000 lbs.	1300	1800	3000	4500	9000
3,000 lbs.	4000	5400	9000	13500	27000

CABLE COME-ALONG

Hand-operated cable winch used for pulling and lifting operations during rescue work. Primarily used in vehicle rescue situations. This is an excellent tool and can be effectively used in conjunction with the air chesel and Hurst rescue tool. Tool nomenclature consists of a 2-ton-rated ratchet assembly with sliding hook, safety shear handles (2), and chains with chain hooks at each end and a pull ring at one end.



1. Safety Shear Handle.
2. Safety Handle Receiver.
3. Ratchet Wheel.
4. Stop Pawl.
5. Cable.
6. Sliding Hook and Sheave Assembly.
7. Anchor Pin.
8. Cable Drum.
9. Hand Wind Knob.
10. Drive Pawl Release.
11. Anchor Hook.
12. Drive Pawl.

WINCH CABLE

Cables vary in size for different applications. The most common cable used on small recreational vehicle winches is a 7 x 19 lay, bright galvanized aircraft cable. This cable is resistant to rust and corrosion, but a light coat of oil prior to use in snow or mud will help prolong cable life. Aircraft cable is the most flexible all-steel cable available due to the small diameter wire used in braiding. This small diameter, while making the cable more flexible, is also more subject to abrasive wear. Care should be taken whenever possible to keep the cable away from rough, hard surfaces. Some states require cables to be rated five times the intended working load. Following is a table for breaking strengths of cable when new.

TENSILE BREAKING STRENGTH MINIMUM
7 x 19 GALVANIZED AIRCRAFT CABLE

CABLE DIAMETER	MINIMUM BREAKING STRENGTH
1/8"	2,000 pounds
5/32"	2,800 pounds
3/16"	4,200 pounds
7/32"	5,600 pounds
1/4"	7,000 pounds
5/16"	9,800 pounds
3/8"	14,400 pounds

WINCHING TIPS

Winching is a hazardous endeavor. Always exercise extreme caution whenever winching operations are in progress. Following is a basic list of "Do's" and "Don'ts" for winching:

DO'S

- Plan your pull. Look at the situation carefully before you even touch the winch. Know what factors are involved. Will the vehicle roll if the cable breaks? Is the winching vehicle safely and se--rely anchored and positioned? A little planning can save alot of trouble.
- Line up the pull so the winch is pulling as straight as possible. Use a snatch block if necessary. Severe angle pulls place much stress on the vehicle frame, winch mounts, cable drum, and cable guide.
- Inspect the cable before attempting to pull a load. Look for flat spots, frays, kinks and rust, since these will severely weaken a cable and may cause cable failure under load.

- Operate any winch with extreme caution. Use a remote control if possible and stand clear of the winch and cable when pulling heavy loads.
- Place a tarp, blanket, or jacket over the winch cable about 15-20 feet behind the hook when winching. In the event of a snapped cable, this acts as a parachute to slow the broken cable end.
- Assist the winch by attempting to drive a stuck vehicle out of the hole, but do not overtake the winch cable. If the cable goes slack, stop the winch immediately, let the winched vehicle come to a stop, then slowly tension the cable before attempting further winch operations.
- Listen to the winch for sounds which indicate excessive loads, snaps, or jerks. Apply winch power intermittently to tension the cable, then apply power smoothly to move the load. If jerked, even a small load can snap a cable due to extremely high instantaneous stress loads.
- Re-spool the cable onto the drum after the winching is completed. This ensures a smooth, even wrap and prevents kinks and flat spots.
- Assume that someone's life may depend on the safely operated machine.

<u>DONT'S</u>

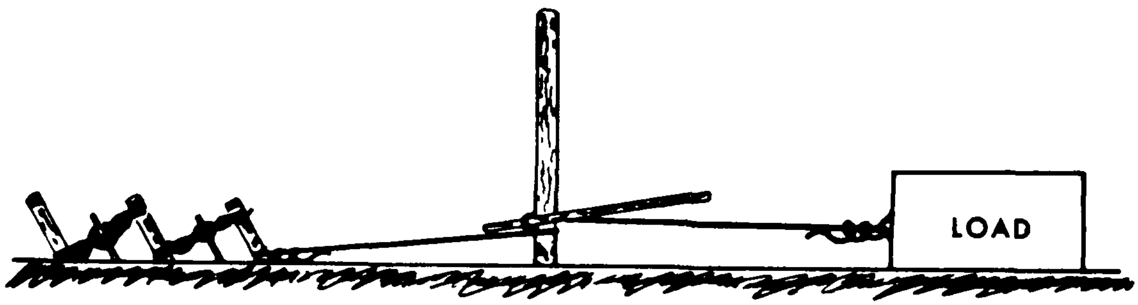
- Use a cable which has kinks, frays, or flat spots, as these severely reduce the tensile strength of the cable.
- Winch with less than five wraps of cable on the drum.
- Loop the cable and hook it to itself -- this may cut the cable. Use a cable sling or choker chain for this purpose.
- Do not hook your winch to the bumper of another vehicle. Always attach winch slings, etc., to an axle or frame member when winching vehicles.
- Use a winch cable as a tow line except in an emergency.
- When anchoring the vehicle to a stationary object (deadman) while winching heavy loads, do not attach to the vehicle any farther away from the winch mounting frame than necessary. Winching from the front while anchoring at the back can twist the vehicle's frame.
- Do not step over or near a winch cable under tension.
- Do not leave a winch in gear when not in use. An accidental engagement of the power could damage the winch or the vehicle.

  Do not let persons unfamiliar with winches operate a winch.

EXPEDIENTS

In the absence of mechanical power or an appropriate tackle, it may be necessary to use makeshift equipment for hoisting or pulling. A Spanish windlass can be used to move a load along the ground; or the horizontal pull from the windlass can be directed through blocks to provide a vertical pull on a load.

In making a Spanish windlass, a rope is fastened between the load to be moved and an anchorage some distance away. A short spar is placed vertically beside this rope, approximately halfway between the anchorage and the load. This spar may be a pipe or a pole, but in either case, should have as large a diameter as possible. A loop is made in the rope and wrapped partly around the spar. The end of a horizontal rod is inserted through this loop. The horizontal rod should be a stout pipe or bar long enough to provide leverage. It is used as a lever to turn the vertical spar. As the vertical spar turns, the rope is wound around it which shortens the line and pulls on the load. The rope leaving the vertical spar should be as near the same level as possible on both sides to prevent the spar from tipping over.



SPANISH WINDLASS

FRICTION BRAKES

In an emergency, almost anything can be used to gain friction to allow the lowering of a load from a height. In the natural world there is nothing wrong with using a tree, projection of rock, blocks of ice or other items which may afford friction. The concern at this point should be the strength of the anchor, the abrasiveness of the surface, the ability to gain more or less friction from the anchor, etc. During times of stress there may be a tendency to forget such things; however. The need for padding may be forgotten until you see a frayed or threatened rope resulting from the rough surface of the brake. Such common items as turnout gear, packs, hose, pike poles, etc., will prove useful when padding and protecting these lifelines.

Also during an emergency, almost anything can be used which may be artificial in nature but very practical for use, such as fire apparatus, ladders, bumpers, chimneys, air conditioner units, TV antennas, etc.

Again, the need is present for strength identification, rough edges and other factors which may be hazardous. Be alert to oily and corrosive substances, screw heads, hooks, sharp edges of metal and other things which may be very dangerous and threaten the integrity of a rope.

CARABINER BRAKES

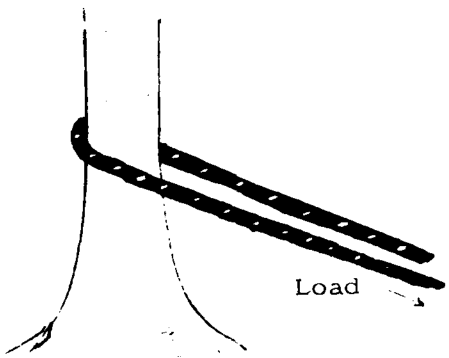
A very common device present in most rescue organizations, and which all rescue personnel should be familiar with, is the carabiner. The carabiner is available in many shapes, sizes, strengths, colors and other variables. The functions are multiple, and when applied to friction brakes, they are very quick, clean, and generally highly useful. Although carabiners are somewhat expensive and easily lost, it is important that the rescue teams have a quantity of these small devices for use at the scene of a heavy rescue. To assemble the brake, one carabiner is clipped across the other with the rope running through one and over the transverse bar of the other. Once learned, it is simple to use and saves wear and tear on the clothing and expenditure of energy. The brake, operated correctly, provides smooth lowering, especially on cliff or high-wall evacuations.

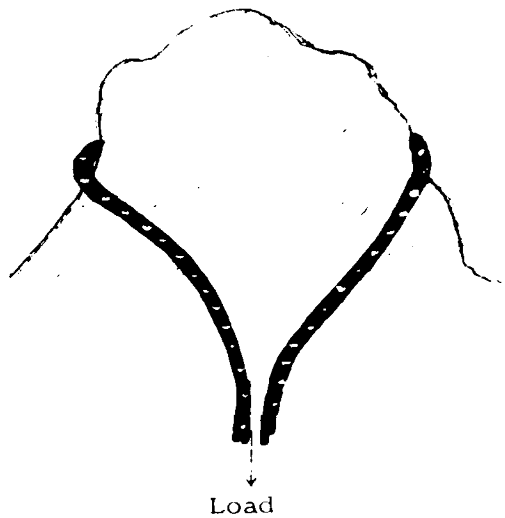
Safety Information and Operating Tips

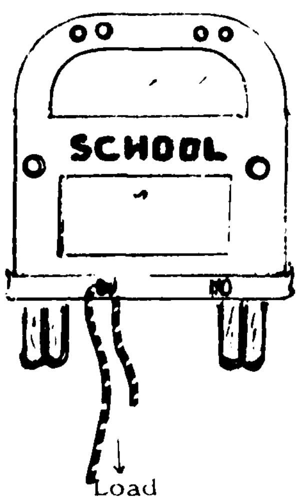
- Rapid lowering may result in overheating of the carabiner due to friction. Lowering should be steady and smooth, with a double brake fitted if the load is heavy. It is possible to melt a nylon rope in two if the rescuer is not careful.
- Check the rope for kinks or knots as these could jam the brake. The rope should be fed into the brake to avoid jamming.
- Remember, the brake is a one-way system. It cannot reverse without releasing the load and feeding back the rope by hand.
- The load on the brake should be constant, as jerking and unloading could result in the braking carabiner slipping down and fouling the brake.
- It is possible to increase the friction and stop the lowering by bringing the control rope forward across the brake. A prusik knot may be tied below the brake on the load rope to give an independent locking system. The other end of the prusik sling should be secured by a knot which can be released while under tension.

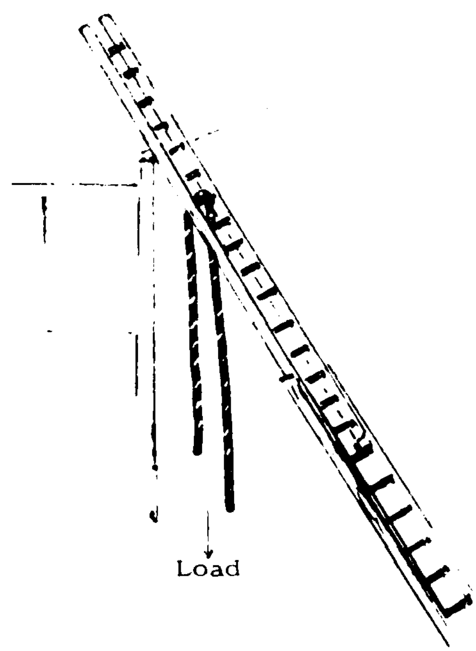
Friction brakes are used in conjunction with other devices in rescue work when it is necessary to lower a heavy load under complete control. Cross bars may be almost anything including claw hammers, tire tools, pike poles, other carabiners and other items which are relatively strong and rigid.

FRICTION BRAKES

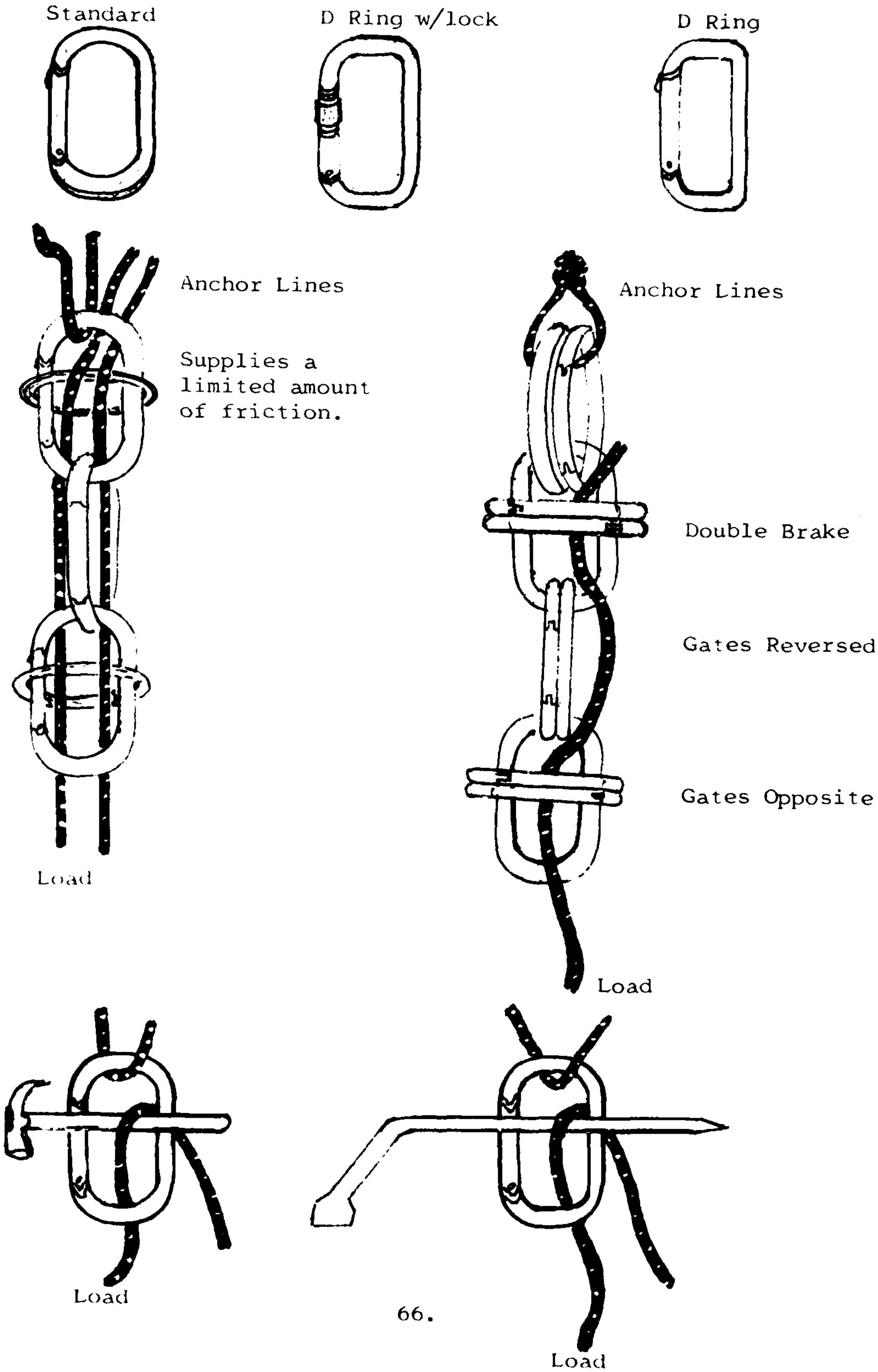








CARABINERS - FRICTION BRAKES



RAPPELLING

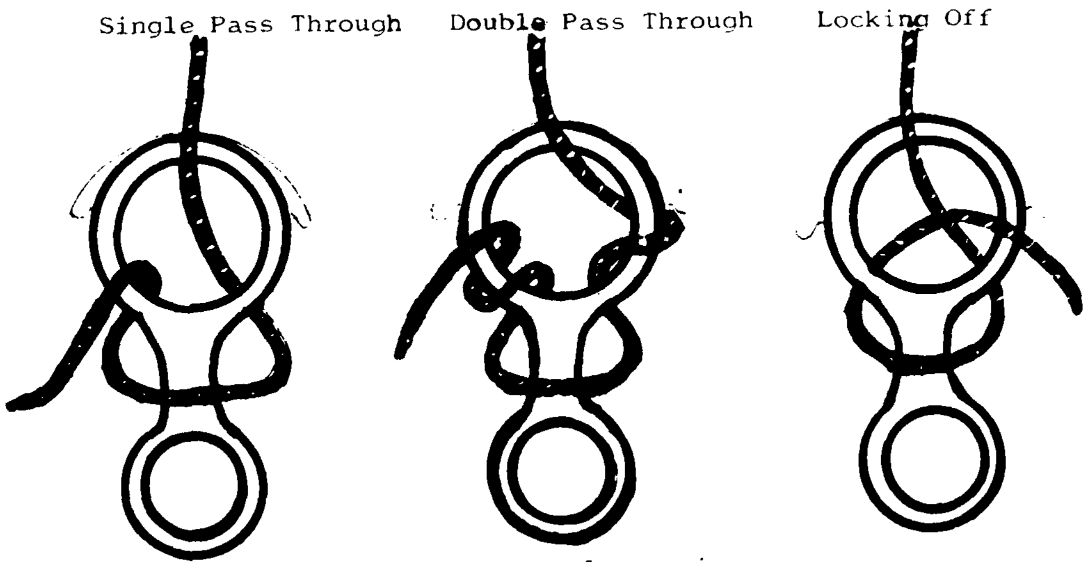
"Rappelling" is a term used to refer to sliding down a rope. There is a variety of equipment and techniques which can be used for this purpose. The basic idea is to suspend a person by a belt or harness, then have a controlled descent using some type or form of friction. The purpose is to provide a reasonably fast and safe method to escape from high places or to rescue trapped victims.

There are four principal devices used by fire departments for the purpose of rappelling: Carabiner; Figures-of-8 Descender; Sky Genie; and the Rack. Regardless of which is utilized, these should, whevener possible, be backed up by a belaying line.

Belay is a nautical term which means to make fast by winding around an object. Belaying is the act of allowing a line to slide in a controlled manner so that it may be stopped at any time. Friction is used to accomplish this control. A belaying line can be set up by wrapping a rope around the body or object or using one of the four rappeling devices anchored to a strong support to provide the desired control.

Figure-of-8-Descender

This type descender was originally designed for mountaineering but has proven to be an excellent rescue tool. After donning an approved rescue harness or tying a swiss seat, the device is fastened to the user by a locking carabiner. Unlike other devices, there is only one way to hook into a Figure-of-8. Figure-of-8, with safety ears, should be chosen when possible because there is less likelihood of knotting should the "8" hand on an edge. The Figure-of-8 is compatible to any rope from 3/4" (21 mm) and smaller. Internal diameter should be a minimum of 2½" to accomplish this goal.



Attach load fasteners to lower ring.

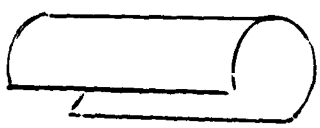
A single pass through is sufficient for one person and a double should be used if a victim is to be picked up. Double knot usually necessary with 3/4" (21 mm) or certain 3/8" (9 mm) ropes.

Locking off is accomplished by bringing the standing portion of the rope over the top of the Figure-of-8 and pulling it sharply down behind the running part. A second wrap behind the "8" and down behind the running part may be necessary to stabilize the typing off. The belaying line can be attached to the Swiss seat/harness or directly to the carabiner holding the Figure-of-8.

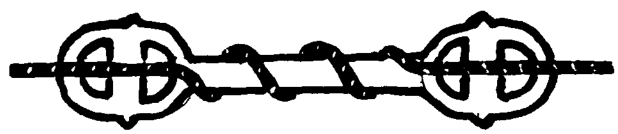
A second "8" can be added above the first, using a carabiner to increase friction if a slight release of tension can be accomplished on the rappelling rope. In this manner, the rescuer can add friction without releasing the first "8" to add another pass through.

Sky Genie

The Sky Genie was originally designed as a body exercise device. The rope that comes with the descent device is usually a single braid nylon, which does not hold up well to abrasion. Generally speaking, two wraps are required when using the Sky Genie.



SHIELD

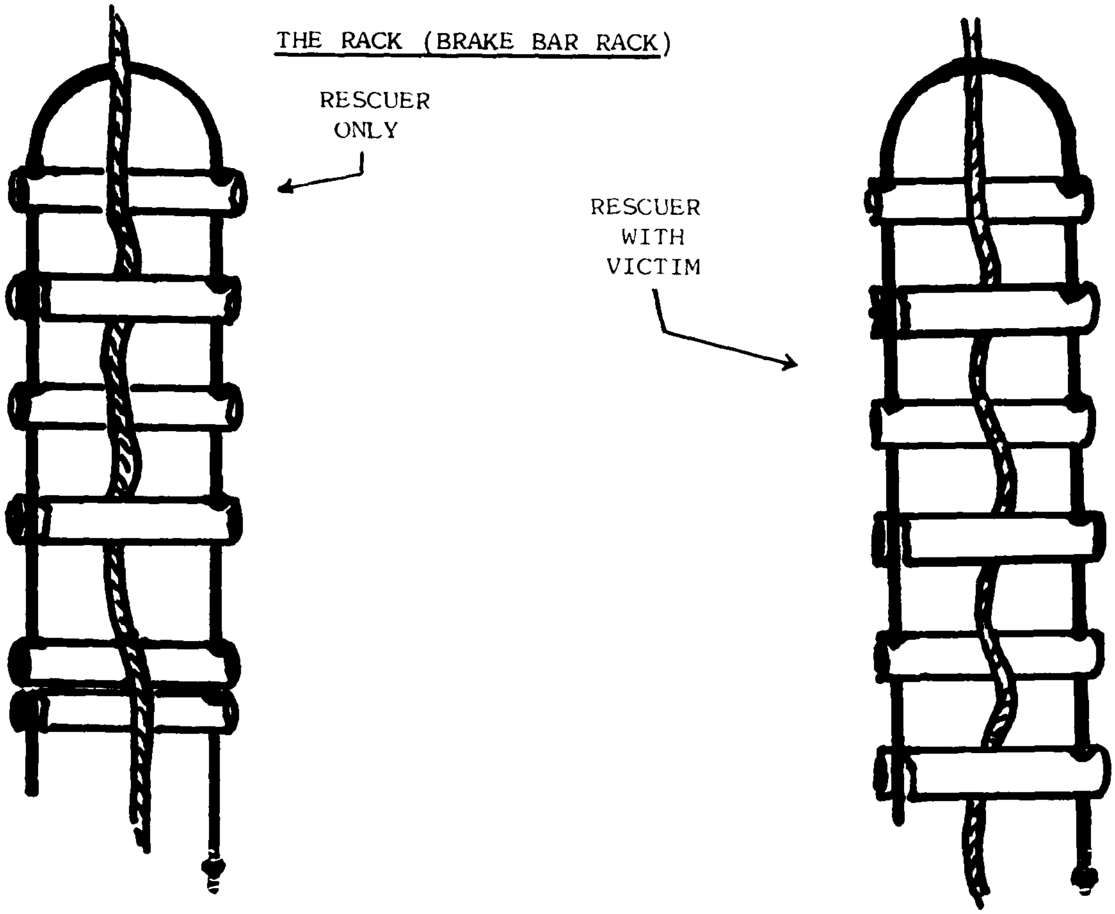


The shield must be affixed firmly into position before use to prevent the rope from becoming unwrapped. The amount of control can be increased by taking more wraps, and is recommended when picking up a victim. Generally the Sky Genie is only used on 1/2" or smaller ropes; however, larger units are available. Locking-off is accomplished in the same manner as with the Figure-of-8. A belaying line is attached to the carabiner or connecting device between the Sky Genie and the rescue harness or Swiss seat.

The Rack (Brake Bar Rack)

The rack was invented during the early 60's as a cave exploring descent tool. It is the only single rappelling device to which more friction can be added or subtracted while tension is still on the life line. Like the Figure-of-8, Sky Genie, carabiner, a Swiss Seat or harness are used in conjunction with the Rack. Generally, four brake bars are used for a single person descent. Two more may be added if necessary after reaching a victim. When using a Rack, be sure the rope is passed through the device so the pressure holds the brake bars against the rack frame, otherwise failure could occur. Tying off follows the same sequence as explained for the Figure-of-8 and Sky Genie. Brake bars will also fit carabiners to build small brake units.

THE RACK (BRAKE BAR RACK)



RAPPELLING AND RESCUE - GENERAL

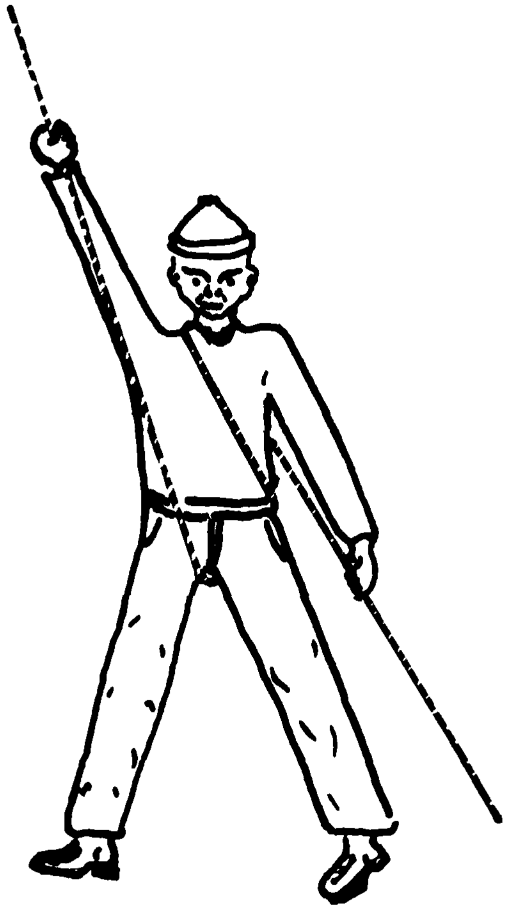
Contrary to popular belief, a rescuer should not make a rapid descent in most situations. Safe rappelling requires a slow descent, walking down the face of the object when possible. Faster descents can be made if necessary. However, they are harder on the rope because of the heat buildup, sudden stops and excessive abrasion.

A victim trapped on a ledge will require quick work. If the victim is in a dangerous position where loss of grip may occur at any moment, drop the first life line down to him/her with loops for grasping or placing arms until you can get set up. Belaying lines must be utilized and the rescuer needs to be prepared to do the job. A rescuer should have a piece of rope or webbing approximately 15 feet long, tied into a continuous loop, and one extra carabiner to attach the sling to your hardware. The belaying line is then passed under one of the victim's arms and he/she is told to grab hold. Using this technique, the victim does not have to move or release a grasp until the rescuer is ready to finish the operation.

BODY RAPPEL

Should a situation ever arise where emergency personnel must descend a rope quickly or with little preparatory time, the body rappel can be used. It is not a comfortable ride, nor is it failsafe, and should

only be used in an extreme life-threatening situation. It is more suited to full turn-out gear rather than work uniforms because of the friction applied to the body, especially in the groin area.

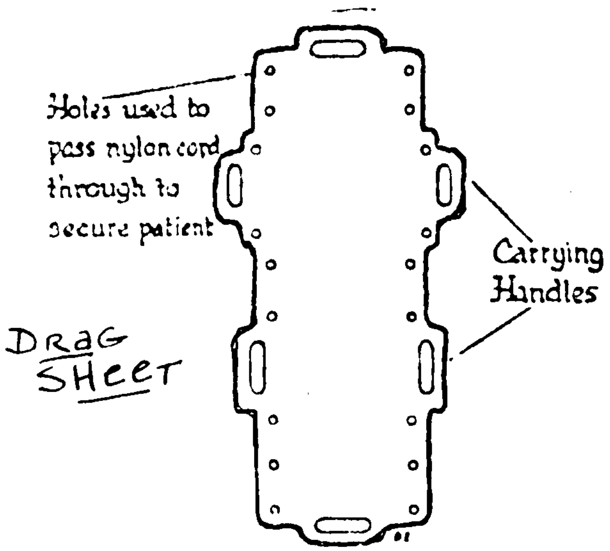


In any life safety situation, the safety of the rescuer is of utmost importance. A few seconds taken to check knots, ropes, anchors, and hardware are well advised. Every system should have a stronger or at least equally as strong back up. The key to successful rescue using ropes and rigging is knowing limitations - Limitation of the equipment and yourself. This can only be accomplished through training. Follow the basic guidelines and keep it simple, and above all safe, for the life you save may be your own.

SPECIAL LITTERS

Rescue demands special tools and resources to accomplish victim transportation. Many conventional litters such as the stokes or basket style will simply not fit through openings in rubble, rock or debris unless extensive, time consuming modification is carried out. Worldwide experience has proven the British Niell Robertson litter adapted with an adjustable steel carrying frame and bridle to be one of the best litters yet devised for this type rescue. Stokes litters are a good second choice. However, in narrow passages they jam easily and will not fit through irregular passages. The green splint style litter may be of some use in restricted passages, but provides no protection to the victim.

Backboards, scoop stretchers, and canvas litters have all proven themselves dangerous when used as sub-surface litters or during vertical lifts. Their use has resulted in death due to failure. The drag sheet is a very simple and effective stretcher in long, low passages but not advised for long carries. Built of heavy canvas material, it can be laced up to provide good support and flexibility. This type stretcher proves very good for transport in long, twisting crawls which would not admit a rigid frame stretcher. It's use should be limited to crawls and horizontal passages. It is not designed for vertical lifting and must be used with an exposure bag in order to prevent hypothermia.

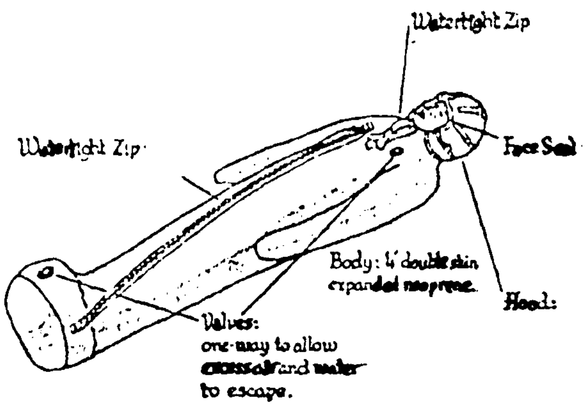


Made from 3/8" or 1/2" Conveyor Belting

VICTIM PROTECTION

Exposure Bag

To prevent hypothermia, all litters should be used in conjunction with an exposure bag. During the course of a cave rescue, exposure bags will also provide ease in victim transfer since it is normal to transfer the victim in and out of the litter during taansport from many caves. An exposure bag may be built from neoprene rubber such as used in diving suits and supplied with a face seal and water-tight zipper. However, heavy plastic "mummy" style bags and even plastic garbage bags have proven their worth in preventing convected, and to some extent, conducted heat loss. Wet suits can also be used to insulate victims in water situations. Wool clothing will also insulate in wet conditions. Down clothing is too easily saturated and rendered useless in caves.



CONSIDERATIONS AND HAZARDS OF AERIAL RESCUE

The heavy rescuer may be called upon to perform a rescue and/or medical evacuation on any number of different types of vertical structures, both above and below ground. There may be no possible way the rescuer will be able to either preplan or train for all of these conceivable types of emergencies. Fortunately for the rescuer there are many similarieies between structures and techniques. The basics of the block and tackle, telpher line, braking systems, anchors, knots, etc., have been discussed elsewhere in this manual. For almost any rescue that might arise involving an electrical tower, water tower, aerial tramway, smokestack, grain elevator, overpass, elevator shaft, radio and TV tower, stadiums, construction projects, cranes, dams, tourist towers, etc., there are common considerations as well as common hazards to avoid.

COMMON CONSIDERATIONS

In any rescue operation there must be someone in charge. This person or someone in authority needs to size up the situation and decide whether the incident is within the scope of the training and expertise of the rescue team. If, at this point the operation is either too difficult or not within the scope of the abilities of the team, it is imperative that the operations leader appreciate and understand this fact. In many areas of the country there are specialized professional and volunteer groups which have the capabilities and equipment to handle certain "exotic" problems. It is important that the operations leader be aware of these organizations. It should be part of the team's preplan to identify some of these resources before the actual operation takes. place. Special mine rescue, cave rescue, military rescue, and other vertical rescue groups are located throughout the country.

"Necessity is the mother of invention." This is particularly true to the rescuer involved in an incident that neither he nor the rescue team has trained for. In aerial rescues this may be particularly true. Once the victim has been reached, whether stranded or hurt on top of a smokestack or a grain elevator, the methods of removing this person are fairly straightforward. The removal may mean the assistance of a helicopter and a trained crew who specialize in this sort of rescue, it may be that a large construction crane or elevating ladder from the fire service will be necessary, or it may be that the victim will be lowered or raised by the use of techniques discussed elsewhere in this manual. Whatever the means of removal, it is paramount that safety to both the victim and the rescue party be foremost in everyone's mind. The question, "what happens if......?" should be constantly asked to consider the many variables which may be encountered. An operation on top of a power pole to remove the live victims of a light plane crash is difficult enough when it is a pleasant day, but when it is raining and dark the problems are compounded drastically. In many of these situations, even though one person may be making the final desisions, it would be wise to have professional assistance at all levels and with all discipline of involvement. The request for assistance of professionals may be important immediately upon learning of the incident. The professional electrician from the local power company will be indispensable when dealing with the plane wreck in the power lines. The maintenance chief from the elevator company will be invaluable when dealing with elevator shaft rescues. The local assistance of the weather forecasters will be very important to determine the length of the particular storm or the potential the storm will have in terms of amounts of rain, snow, etc. The local search and rescue organizations may prove very beneficial when dealing with a cave rescue, a cliff rescue, or possibly an aerial tramway rescue. Not all situations can be trained for, may be beyond the capabilities of the heavy rescue team, etc. Do not allow pride and ignorance to interfere with the saving of a life, either your own or that of the victim.

The operation will dictate the type of equipment necessary for the successful and safe rescue. Whether someone is being lowered or raised from the side or top of a high rise building, the inside of an aerial tramway or a tourist tower, the equipment will be essentially the same. It is imperative the rescuer be very familiar with the equipment available and its limitations. Common to all of these rescues will be the need for the identification of safe and strong anchors. These will, of course, vary with the structure involved. Regardless of what anchor is used, it is essential that the point of attachment be sufficiently strong to support the weight of all involved. If you err, do so on the side of safety. Sharp and abrasive edges and faces need to be avoided at all costs. Be alert to small things such as nylon rope rubbing against nylon rope in a sawing action. Be alert to caustic or acidic substances capable of dissolving a rope or webbing.

When employing an anchor, have someone present to monitor the anchor site. There is a need to be alert for falling objects -- objects that can be dislodged by the rescue party, the victim, or outside sources. It does not take a brick traveling very far to become lethal. It is critical that all members of a vertical rescue team wear approved hard hats. Even then, these may be insufficient to prevent a serious or fatal accident. A very common problem is the dropping of items by the rescue party onto the victim or others below. The situation may be an adrenalin-producing one and in the excitement, members of the rescue team will be even more clumsy. The item dropped may be crucial to the operation. For these type items, it is wise to secure them by a cord to prevent irretrievable loss. When all seems to be in place, it is critical that those involved know exactly what their particular role is and what each of the other member roles are. This is a product of continued training and teamwork. Once the victim is reached, it is important to let him know what is going on, what the general plan is, and other necessary information. It may be that the victim will be of assistance to the rescuer, and will most definitely be a hindrance unless taken into the rescuer's confidence.

When a victim is being extricated, it is good rescue practice to have a second person inspect the systems involved and troubleshoot any of the potential sources of error. You will have gained a second "opinion" as well as added confidence and security to the operations. A vital aspect of an aerial operation is communications. This, of course, is important with all aspects of rescue work. Work out all sources of error prior to beginning the operation. If voice signals are to be used, make sure all involved know the commands and all possibilities. This is true for hand commands as well. If artificial communications are to be used, insure the equipment is in operating condition with spare batteries if necessary. When part of the rescue team is on top of a 400-foot radio aerial, it is very important to know their needs at all times. If vital pieces of equipment are necessary, it is desirable to take a spare of that item. If anything can go wrong, it will do so during the most critical part of any operation.

Due to the special nature of the high rise rescue, it is imperative that the actual rescuers (those taking the stretcher over the lip of the roof) be very conscious of their limitations and paranoias. There are members of rescue groups who are very involved with egos, prejudices, fears, etc., which may interfere with a safe and successful operation. Many people absolutely cannot swing out over an open space, dangling from a rope. Many people suffer from claustrophobia and would be a serious detriment to an operation inside a water tower, elevator shaft, dumbwaiter, pipe, mine, etc. It is crucial that the operations leader understand and be aware of those personnel with these limitations. It is also important that the sufferers of these problems be analytical and honest enough to identify themselves at these crucial mements. Operations have suffered because an individual had too much pride to admit he was afraid of heights, etc. The operations leader needs to appreciate the members of his organization who are too quick to volunteer for a high rise evacuation. It might be prudent to look for someone who is a little more cautious.

COMMON HAZARDS

Some hazards have already been mentioned -- personal fears and egos, falling objects, lack of communications, lack of command, inability to utilize outside professional expertise, sharp edges and lack of strong anchors. Other hazards to be aware of are inappropriate tools for the task at hand, nylon rope around hot objects, and the inability to improvise on the scene. When things change or are not as they appear, it becomes very important to shift with the problem. When the rain starts and the team is not prepared, this may add a new dimension which could be at minimum, bothersome and at maximum, fatal. Proper clothing and footwear for the incident is very important. It is poor practice to be scrambling around the top of a TV antenna wearing turnout gear. The limitations of this type situation are obvious and very hazardous. Be very conscious of the flooring and/or supports upon which you are working. The rescuer needs to know where the victim is at all times to avoid further injury, dropping items, etc.

SPECIAL PROBLEMS AND CONSIDERATIONS OF VERTICAL RESCUE

When raising or lowering a person or several people, it is imperative that a double-safe system be employed. It is one thing to be rescuing someone who is already injured; it is quite another to get a member of the rescue party injured also. This obviously complicates the problem and will very likely put everyone in much more jeopardy. There are a few special problems which should be known when dealing with raising and lowering operations, whether off a cliff face or a high rise building.

- All parts of the system need to be checked by the site operation leader and preferably the person who is being lowered or raised along with the victim. This insures a failsafe system and will also lend confidence to the rescuer who will be accompanying the victim. All anchors may need to be reinforced, all knots inspected and possibly backed up, all ropes checked, and all lights in operable condition. All aspects of the operation must be under heavy scrutiny and made as safe as is humanly possible.

There may be a tendency to "overkill" on safety. This may be a function of time and experience. This overkill may be an actual detriment by making the system, in whatever form, too ponderous or unwieldy.

- The victim needs to be appraised of what is expected of him, how he may assist, and what the general plan is going to be. His psychological reassurance is imperative for a smooth and safe operation. Potential problem areas may need to be explained to the victim -- such things as unexpected noises, drops, unfamiliar terms or techniques may all need to be explained for the victim. The fact that the victim may panic at the last moment could be lethal for all involved. With the victim's cooperation, the operation may be much easier

- All movements and sequences of the raising or lowering should be as smooth as possible. All members of the team must be cognizant of what is taking place, what is expected of them, and what to expect of their team members. Insure that the operation leader is known by all involved and is being paid attention to.

- If the stretcher is being tended, it is the function of the attendant to get to the victim, to see that the victim is properly loaded and secured, to give the victim a smooth evacuation by preventing the loaded litter from knocking against the building or loose rock, and to administer the required first aid.

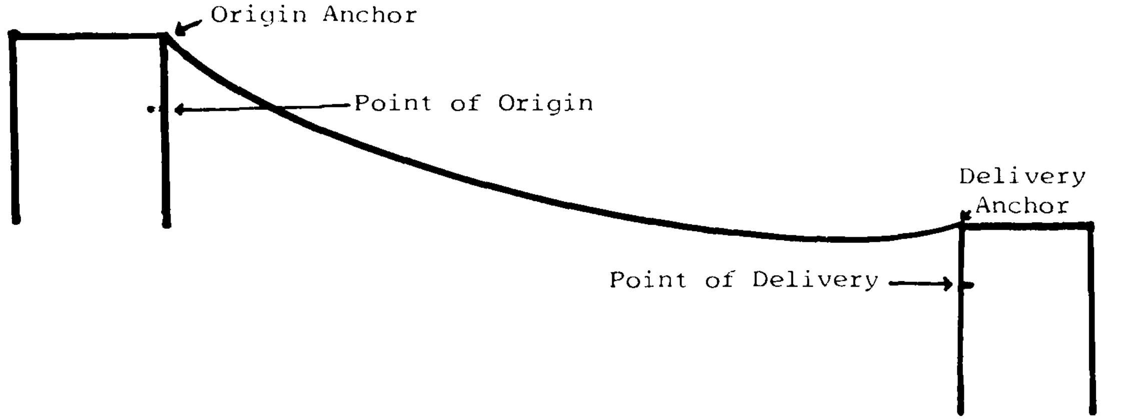
Some of this detail may only be learned by actual raising and lowering training, with the rescuer playing the part of the victim. From the victim's eyes, it is possible to see the weak points and inefficient areas of the operation. The attendant needs to be the first aid or paramedic person available with the skills and tools necessary to do the job. It is not necessary for the most skilled medical person available to be in attendance if the injury is not particularly severe or life-threatening. This professional may be better utilized at the point where the litter comes to rest. The stretcher tender needs to be very alert to good first aid principles; in particular, the maintenance of a good airway. An individual who is lashed into a stretcher and has to vomit is in a very awkward and potentially fatal position. This sort of problem needs to be preplanned before the victim is even placed into the stretcher.

- The decision must be made as to whether there will be one or two litter attendants. There are pros and cons for having both. The more people hanging on the end of the rope the more room for trouble. On the other hand, the fewer people on the end of the rope may mean that a problem which arises out on the wall may not be manageable; possibly resulting in a death.

- Communications is often the largest problem in any rescue and certainly should be a major consideration in a raising or lowering operation. The speed of raising the litter needs to be determined. The fact that the raising party knows the victim and litter attendant need to stop for some reason, or have been "hung" up by some projection or problem is vitally important. The team needs to be synchronized so that one aspect of the operation is not held up significantly because the other part of the team was not ready for them. It may not do much good to get the victim off the building top only to remain at the base of the building for a long time while waiting for an ambulance.

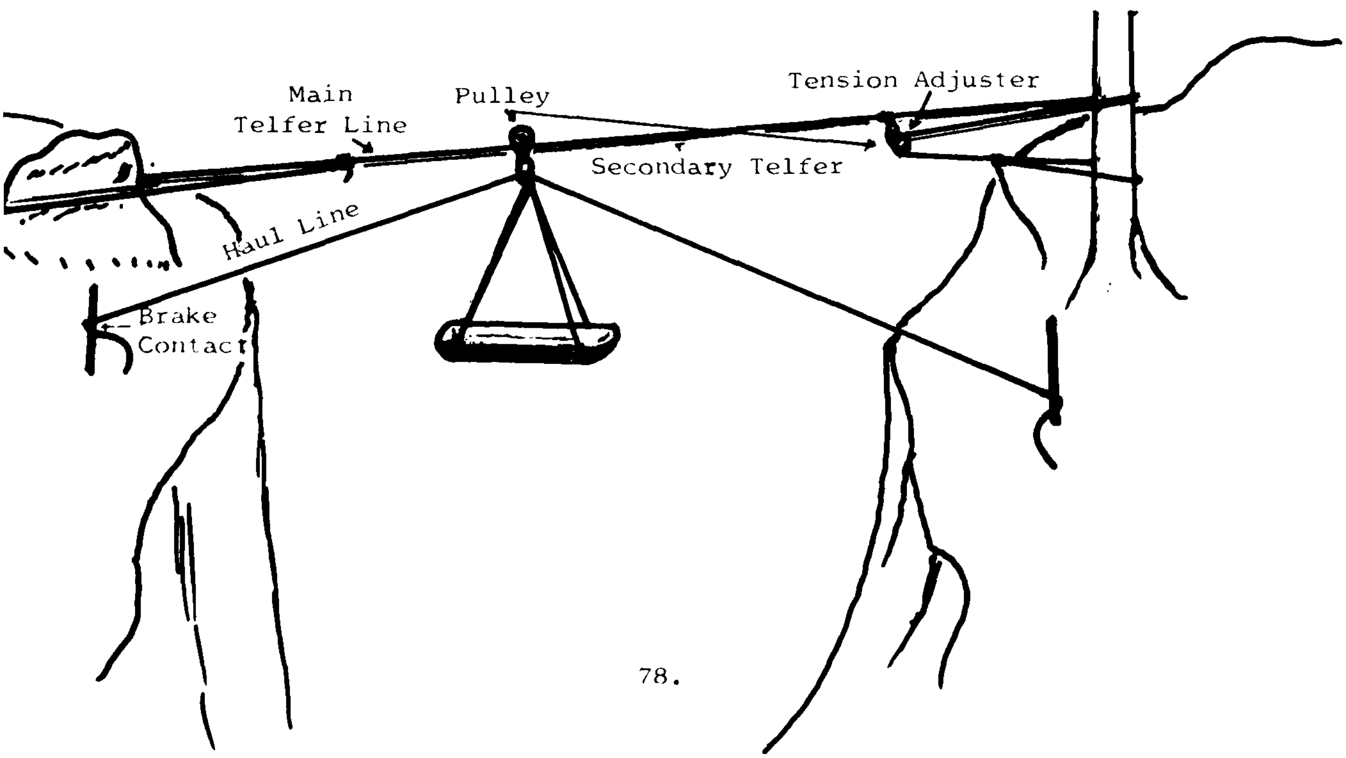
The overriding theme in an operation where someone is being raised or lowered needs to be COMMON SENSE. Regardless of what the book says, there will be times in the career of most rescue personnel when the particular problem will not fit the stereotyped "book" answer. This is where preplanning and improvisational ability of the rescue team will be stressed. It is the well-prepared team that will be able to "bend" with the problem and "create" the answer.

THE TELPHER OR TYROLEAN



The Telpher line is an excellent way to transfer large numbers of casualties over difficult and dangerous terrain, or between two structures. Use prusik knot or gibbs with small diameter rope for attaching tension adjuster to main line. The small diameter rope or the prusik knot will slip before the main line fails.

The telpher requires an extremely strong non or low-stretch rope or cable. Only steel or static kernmantle nylon rope should be considered. Others are too weak in energy absorption and tensile strength. The litter or stokes should be slung so the victim cannot reach the carabiner or rescue pulley, approximately 3' between the litter or stokes and the pulley. Rope should be static type kernmantle to eliminate excessive sag or stretch.



Good anchors are also a requirement since the loads are abnormally high and act in both directions. As a rule, each anchor will be subjected to a force of twice the anticipated load with the entire line being subjected to a minimum of twice the load. For this reason, one should be very proficient at proper anchor selection and theory as covered earlier. The anchors selected must also provide for a reasonable difference in elevation above both the point of origin (where the victims will be taken from) and the point of delivery (where the victim will arrive).

The lower anchor, at the delivery point, will need to have a come-along or similar system attached so tension may be adjusted in either direction. Because of the relative high dynamic forces, a combination safety and haul-line should be employed to control the victim's/litter's travel on the main line. One rescuer on each end shall tend this line and be alert at all times. Friction brakes should be set up to control travel. If the point of victim's removal is extremely hazardous, where no access is available, a secondary main line is advised.

The rigging of the litter to the telpher should be accomplished with a locking rescue pulley (normal swerve blocks require careful threading, can't be readily attached and/or can come open unless properly rigged). To the rescue pulley, attach the litter bridle by use of a carabiner (locking style) so the litter may be quickly attached or detached from the pulley unit. Also attach the safety-haul line to insure it's stability and victim security.

Communications are essential and one rescuer must be placed in charge of the operations to give commands. A whistle is suggested as an excellent signal/communications tool based on the O.A.T.H. system of signals. A variation of the telpher can be used to accomplish victim removal from intermediate points between the two principal rigging points; i.e., a building or a person mid-river in a debris jam.

The technique is to slacken the telpher line, holding fast to the haul/safety line. To lower the litter to rescuer, the mechanical advantage system as used to adjust tension can then pick up a victim by reapplying tension to the telpher. The tension adjuster should have no more than a 3-to-1 mechanical advantage.

R I G G I N G

GUYLINES

Guylines are ropes or chains attached to an object to steady, guide, or secure it. The lines leading from the object or structure are attached to an anchor system. When a load is applied to the structure supported by the guylines, a portion of the load is passed through each supporting guyline to its anchor. The amount of tension on a guyline will depend on the main load, the position and weight of the structure, the alignment of the guyline with the structure and the main load, and the angle of the guyline. For example, if the supported structure is vertical, the stress on each guyline is very small, but if the angle of the structure is 45°, the stress on the guylines supporting the structure will increase considerably. The number and size of guylines required depends on the type of structure to be supported and the tension or pull exerted on the guylines while the structure is being used.

Number of Guylines

Usually a minimum of four guylines are used for ginpoles and two for shears. The guylines should be evenly spaced around the structure. In a long slender structure it is sometimes necessary to provide support at several points in a tiered effect. In such cases, there might be four guylines from the center of a long pole to anchorage on the ground and four additional guylines from the top of the pole to anchorage on the ground.

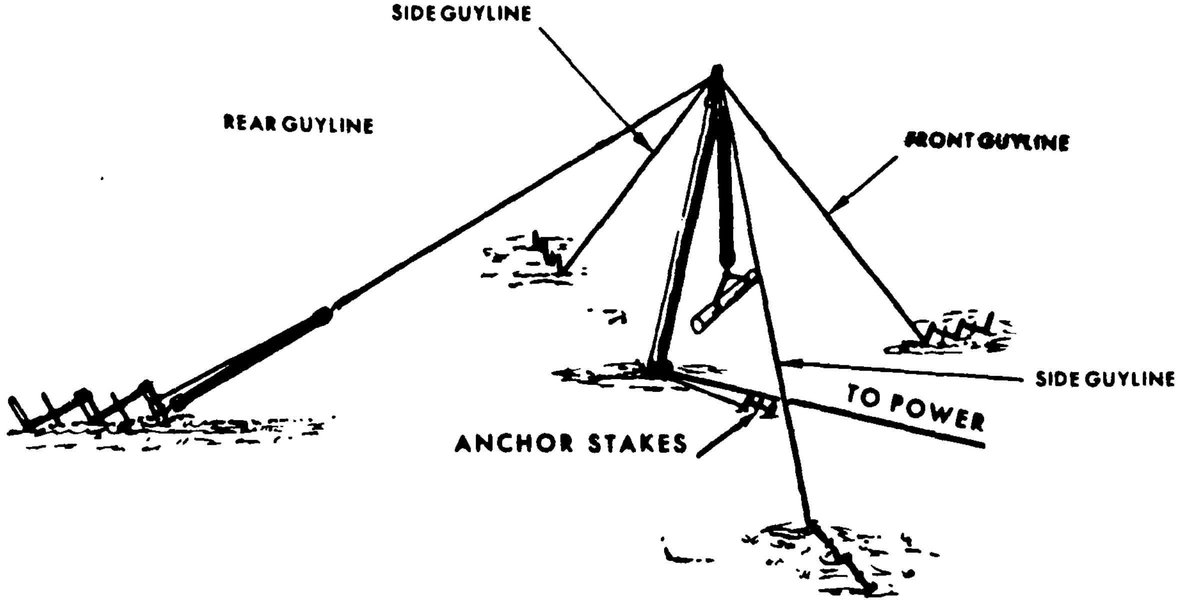
Tension

The tension that will be exerted on the guylines must be determined beforehand in order to select the proper size and material to be used. The maximum load or tension on a guyline will result when a guyline is in direct line with the load and the structure. This tension should be considered in all strength calculations of guylines. Following is the formula for determining this tension for ginpoles and shears:

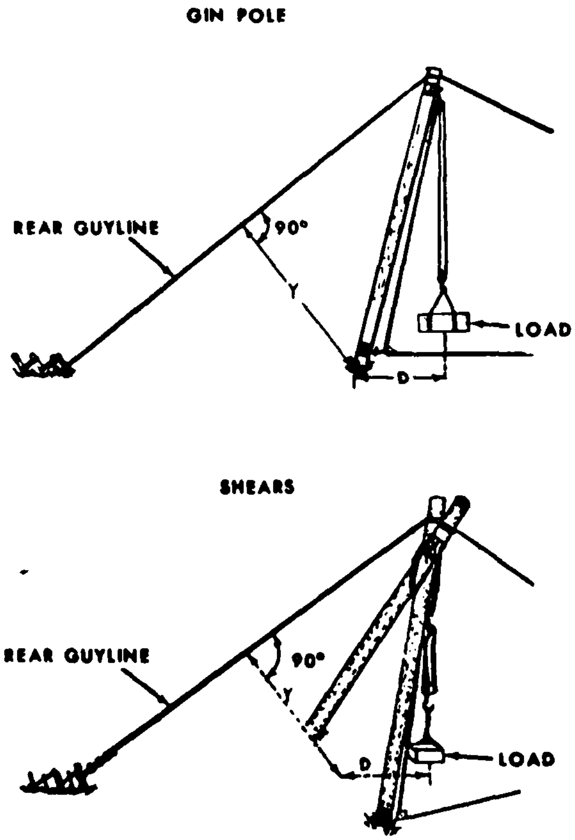
$$T = \frac{(Wl + \frac{1}{2} Ws)\ D}{Y}$$

Size of Guyline

The size of the guyline to be used will depend on the amount of tension to be placed on it. Since the tension on a guyline may be affected by shock loading, and its strength affected by knots, sharp bends, age, and condition, the appropriate safety factors must be incorporated. Therefore, a rope chosen for the guyline should have a safe working capacity equal to or greater than the tension placed on the guyline.



Typical guyline installations.



Ginpole and shears.

T = Tension in guyline
W_L = Weight of the load
W_s = Weight of spar or spars
D = Drift distance, measured from the base of the ginpole or shears to the center of the suspended load along the ground.
Y = Perpendicular distance from the rear guyline to the base of the gin pole or for a shears, to a point on the ground midway between the shearlegs.

Sample problem.

REQUIREMENT I: *Gin Pole:*

a. Given: Load (W_L) = 2,400 lb
Weight of spar (W_s) = 800 lb
Drift distance (D) = 20 ft

b. Solution: $T = \frac{(W_L + \frac{1}{2}W_s)\,D}{Y}$

$= \frac{(2400 + \frac{1}{2}\,(800))\;20}{28} = 2{,}000$ lb tension in the rear or supporting guyline.

REQUIREMENT II: *Shears:*

a. Given: The same conditions exist as in requirement I, except that there are *two* spars, each one weighing 800 lb.

b. Solution: $T = \frac{(W_L + \frac{1}{2}\,W_s)\,D}{Y} = \frac{(2400 + \frac{1}{2}\,(800 + 800))\;20}{Y}$

$= 2{,}285$ lb

Note. The reason the shears produced a greater tension in the rear guyline was due to the weight of an additional spar.

Anchorage Requirements

An ideal anchorage system should be designed to withstand a tension equal to the breaking strength of the guyline attached to it. If a 3/8-inch diameter manila rope is used as a guyline, the anchorage used must have the capability of withstanding a tension of 1,350 pounds which is the breaking strength of the 3/8-inch diameter manila rope. If picket holdfasts are used, it would require at least a 1-1 combination (1,400 lb. capacity in ordinary soil). The guyline should be anchored as far as possible from the base of the installation to obtain a greater holding power from the anchorage system. The recommended minimum distance from the base of the installation to the anchorage for the guyline is twice the height of the installation.

GIN POLE

A gin pole consists of an upright spar, guyed at the top to maintain it in a vertical or near vertical position and equipped with suitable hoisting tackle. The vertical spar may be timber, wide-flange steel beam, railroad rail, or similar members of sufficient strength to support load to be lifted. The load may be hoisted by hand tackle or by engine-driven hoists. It is suitable for raising loads of medium weight to heights of 10 to 50 feet where only a vertical lift is required. The gin pole may also be used to drag loads horizontally toward the base of the pole in preparation for a vertical lift. It cannot be drifted (inclined) more than 45 degrees from the vertical or 7/10 the height of the pole, nor is it suitable for swinging the load horizontally. The length and thickness of the gin pole depends on the purpose for which it is installed. It should not be longer than 60 times its minimum thickness because of the tendency to buckle under compression. A usable rule is to allow five feet of pole for each inch of minimum thickness. The following table lists values for the use of spruce timbers as gin poles.

Safe Capacity of Spruce Timber as Gin Poles in Normal Operations

Size of timber in inches	Safe capacity in pounds for given length of timber					
	20 feet	25 feet	30 feet	40 feet	50 feet	60 feet
6 dia	5,000	3,000	2,000			
8 dia		11,000	8,000	5,000	3,000	
10 dia	31,000	24,000	16,000	9,000	6,000	
12 dia			31,000	19,000	12,000	9,000
6 x 6	6,000	4,000	3,000			
8 x 8		14,000	10,000	6,000	4,000	
10 x 10	40,000	30,000	20,000	12,000	8,000	
12 x 12			40,000	24,000	16,000	12,000

Note. Safe capacity of each le of shears or tripod is seven-eights of the value given for a gin pole.

Rigging a Gin Pole

In rigging a gin pole, lay out the pole with the base at the spot where it is to be erected. In order to make provisions for the guylines and tackle blocks, place the gin pole on cribbing for ease of lashing. The following illustration shows the lashing on top of a gin pole and the method of attaching guys. The procedure is as follows:

1. Make a tight lashing of eight turns of rope about one foot from the top of the pole, with two of the center turns engaging the hook of the upper block of the tackle. Secure the ends of the lashing with a square knot. Nail wooden cleats (boards) to the pole flush with the lower and upper sides of the lashing to prevent the lashing from slipping.

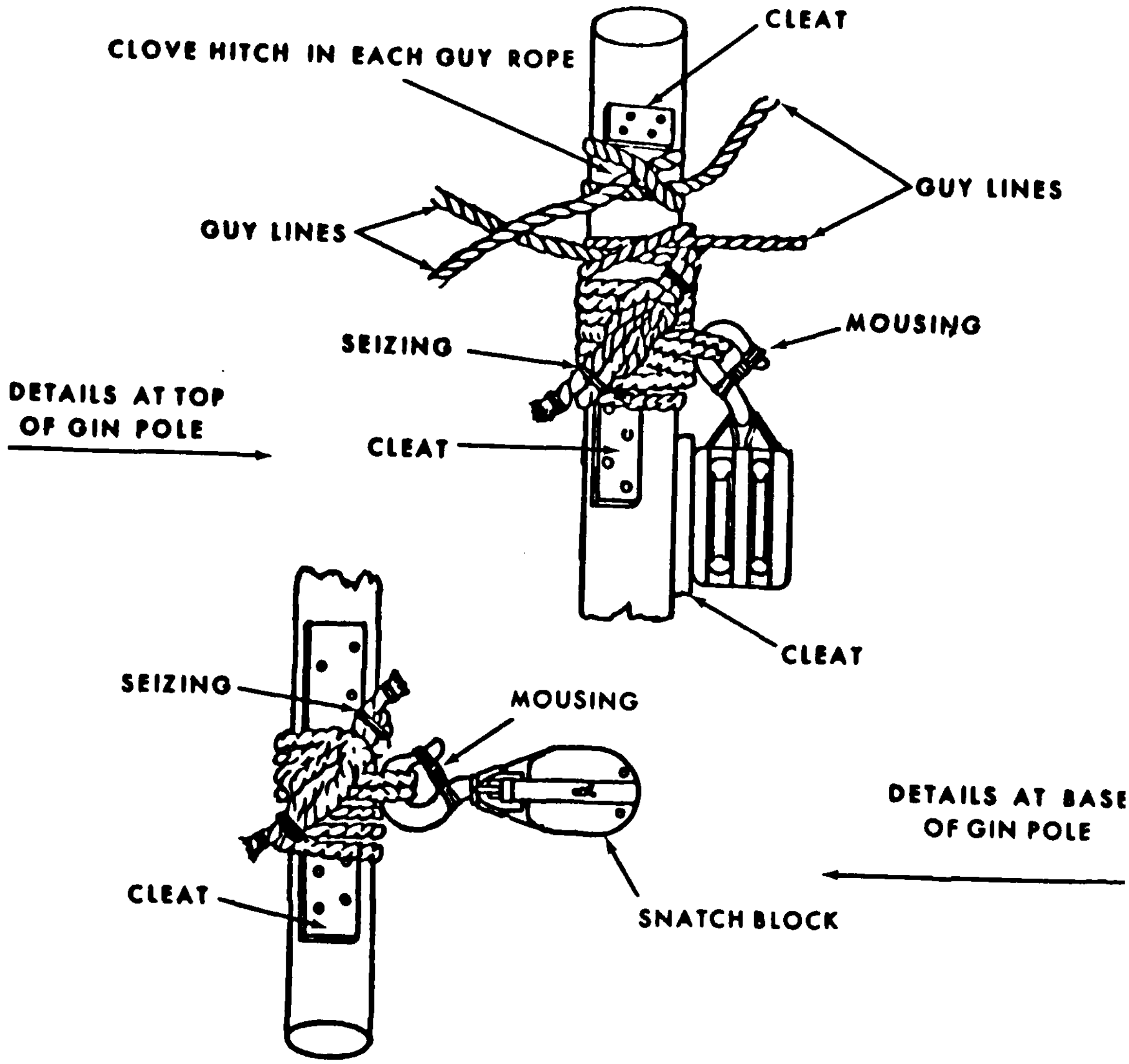
2. Lay out guy ropes, each four times the length of the gin pole. In the center of each guy rope, form a clove hitch over the top of the pole next to the tackle lashing, and be sure the guylines are aligned in the direction of their anchors.

3. Lash a block to the gin pole about two feet from the base of the pole, the same as was done for the tackle lashing at the top, and place a cleat above the lashing to prevent slipping. This block serves as a leading block on the fall line which allows a directional change of pull from the vertical to the horizontal. A snatch block is the most convenient type to use for this purpose.

4. Reeve the hoisting tackle and use the block lashed to the top of the pole so the fall line can be passed through the leading block at the base of the gin pole.

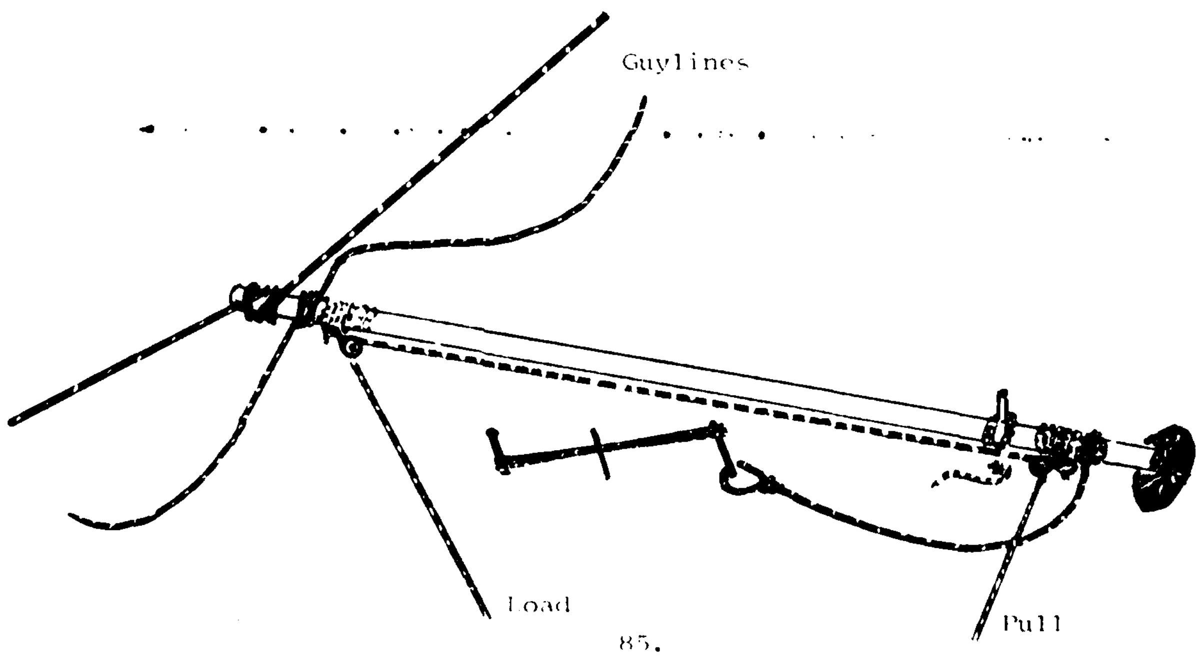
5. Drive a stake about 3 feet from the base of the gin pole. Tie a rope from the stake to the base of the pole below the lashing on the leading block and near the bottom of the pole. This is to prevent the pole from skidding while it is being erected.

6. Check all lines to be sure they are not snarled. Check all lashings to see they are made up properly, and see that all knots are tight. Check the hooks on the blocks to see they are moused properly. The gin pole is now ready to be erected.


CLEAT
CLOVE HITCH IN EACH GUY ROPE
GUY LINES
GUY LINES
MOUSING
SEIZING
DETAILS AT TOP
OF GIN POLE
CLEAT
CLEAT
SEIZING
MOUSING
DETAILS AT BASE
OF GIN POLE
CLEAT
SNATCH BLOCK

A gin pole 40 feet long may be raised easily by hand, but longer poles must be raised by supplementary rigging or power equipment. The number of men needed depends on the weight of the pole. The procedure is as follows:

1. Dig a hole about 2 feet deep for the base of the gin pole.
2. String out the guys to their respective anchorages and assign a man to each anchorage to control the slack in the guyline with a round turn around the anchorage as the pole is raised. If it has not been done already, install an anchorage for the base of the pole.
3. Keep a slight tension on the rear guyline and on each of the side guylines, haul in on the fall line of the tackle system, while men raise the top of the pole by hand until the tackle system can take control.
4. The rear guyline must be kept under tension to prevent the pole from swinging and throwing all its weight on one of the side guys.
5. When the pole is in its final position (approximately vertical or inclined) make all guys fast to their anchorages with the round turn and two half hitches. It frequently is desirable to double the portion of rope used for the half hitches.
6. Open the leading block at the base of the gin pole and place the fall line from the tackle system through it. When the leading block is closed, the gin pole is ready for use. If it is necessary to move (drift) the top of the pole without moving the base, it should be done when there is no load on the pole, unless the guys are equipped with tackle.



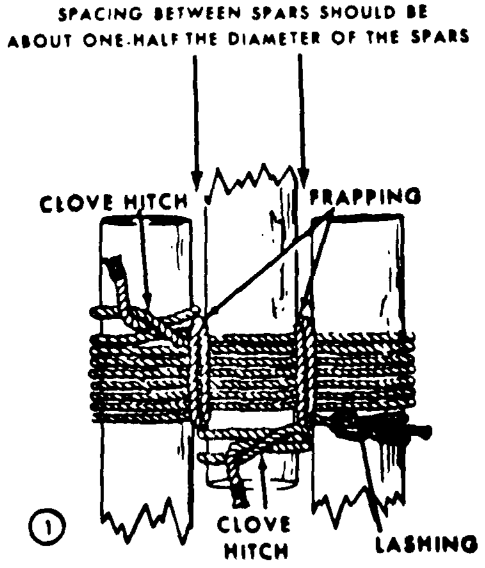
TRIPOD

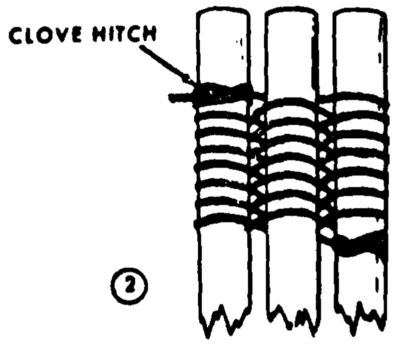
A tripod consists of three legs lashed or secured at the top. The advantage of the tripod over other rigging installations is its stability and that it requires no guylines to hold it in place. Its disadvantage is that the load can be moved only up and down. The load capacity of a tripod is approximately one and one-half times that of shears made of the same size material.

Rigging/Lashing a Tripod

There are two methods of lashing a tripod, either of which is suitab provided the lashing material is strong enough. The method describe below is for rope one inch in diameter or smaller. Since the streng of the tripod is affected directly by the strength of the rope and the lashing used, more turns than described below should be used for extra heavy loads and fewer turns can be used for light loads.

1. Select three spars of approximately equal size and place a m near the top of each spar to indicate the center of the lash
2. Lay two of the spars parallel with their tops resting on a skid or block and a third spar between the first two, with the butt in the opposite direction and the lashing marks on all three in line. The spacing between spars should be about 1/2 the diameter of the spars. Leave the space between the spars so the lashing will not be drawn too tight when the tripod is erected.
3. With rope, make a clove hitch around one of the outside spars about 4 inches above the lashing mark and take eight turns of the line around the three spars. Be sure to maintain the space between the spars while making the turns.
4. Finish the lashing by taking two close frapping turns around the lashing between each pair of spars. Secure the end of t rope with a clove hitch on the center spar just above the lashing. Frapping turns should not be drawn too tight.





Lashing for a

Alternate Method of Lashing a Tripod

1. An alternate procedure can be used when slender poles not mo than 20 feet long are being used, or when some means other than hand power is available for erection.

2. Lay the three spars parallel to each other with an interval between them slightly greater than twice the diameter of the rope to be used. Rest the tops of the poles on a skid so that the ends project over the skid approximately two feet a the butts of the three spars are in line.

3. Put a clove hitch on one outside leg at the bottom of the position the lashing will occupy which is approximately two feet from the end. Weave the line over the middle leg, unde and around the outer leg, under the middle leg, over and around the first leg, and continue this weaving for eight turns. Finish with a clove hitch on the outer leg.

Erecting a Tripod

The legs of a tripod in its final position should be spread so that each leg is equidistant from the others. This spread should not be less than one-half nor more than two-thirds of the length of the legs. Chain, rope, or boards should be used to hold the legs in this position. A leading block for the fall line of the tackle may be lashed to one of the legs. The procedure is as follows:

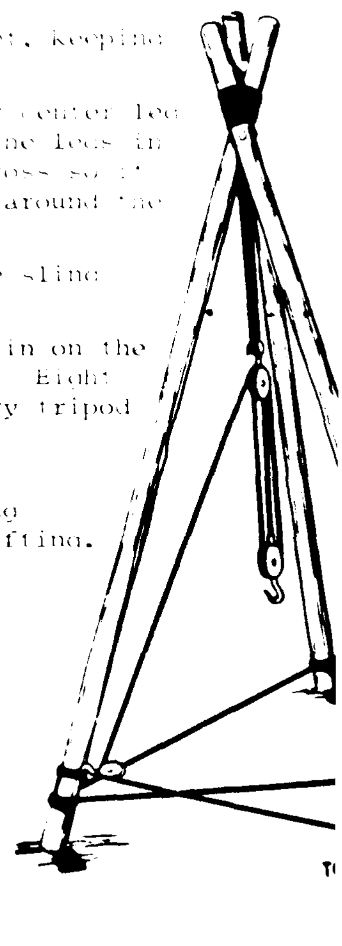
1. Raise the tops of the spars about 4 feet, keeping the base of the legs on the ground.

2. Cross the two outer legs. The third or center leg then rests on top of the cross. With the legs in this position, pass a sling over the cross so it passes over the top or center leg and around the other two.

3. Hook the upper block of a tackle to the sling and mouse the hook.

4. Continue raising the tripod by pushing in on the legs as they are lifted at the center. Eight men should be able to raise an ordinary tripod into position.

5. When the tripod legs are in their final position, place a rope or chain lashing between the legs to hold them from shifting.



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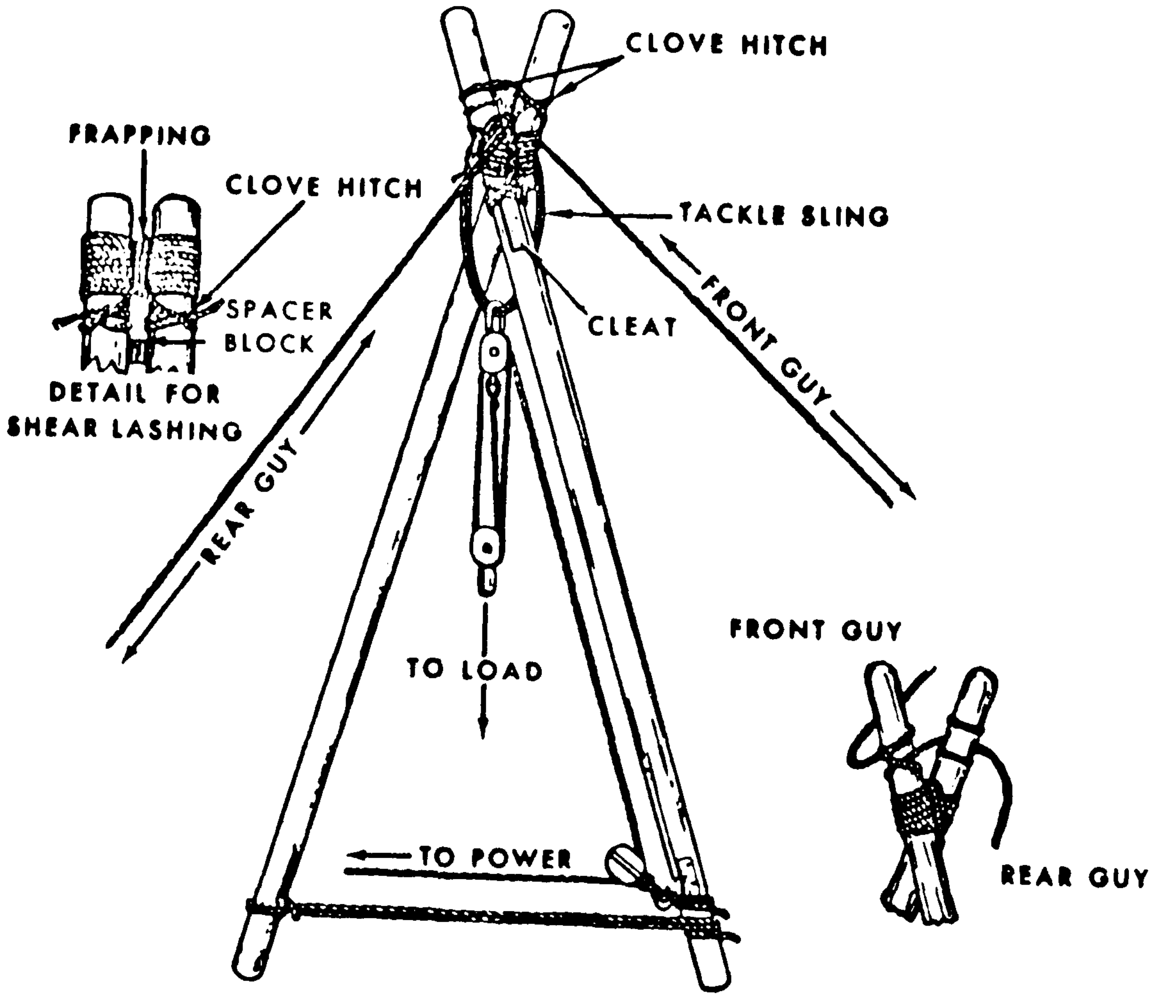
SHEARS (A-FRAME)

Shears made by lashing two legs together with a rope are well adapted for lifting heavy machinery or other bulky loads. It is formed by two members crossed at their tops, with the hoisting tackle suspended from the intersection. The shears must be guyed to hold it in position. The shears are quickly assembled and erected. It requires only two guys, and is adapted to working at an inclination from the vertical. The shear legs may be round poles, timbers, heavy planks, or steel bars, depending on the material at hand and the purpose of the shears. In determining the size of the members to be used, the load to be lifted and the ratio of the length and diameter of the legs are the determining factors. For heavy loads the length-diameter (L/D) ratio should not exceed 60 because of the tendency of the legs to bend rather than to act as columns. For light work, shears can be improvised from two planks or light poles bolted together and reinforced by a small lashing at the intersection of the legs.

Rigging Shears

In erection, the spread of the legs should equal about one-half the height of the shears. The maximum allowable drift (inclination) is 45°. Tackle blocks and guys for shears are essential. The guy ropes can be secured to firm posts or trees with a turn of the rope so the length of the guys can be adjusted easily. The procedure is as follows:

1. Lay two timbers together on the ground in line with the guys, with the butt ends pointing toward the back guy and close to the point of erection.
2. Place a large block under the tops of the legs just below the point of lashing and insert a small spacer block between the tops at the same point. The separation between the legs at this point should be equal to one-third the diameter on one leg, to make handling of the lashing easier.
3. With sufficient rope for 14 turns around both legs, make a clove hitch around one spar, and take 8 turns around both legs above the clove hitch. Wrap the turns tightly so the lashing is made smooth and without kinks.
4. Finish the lashing by taking two frapping turns around the lashing between the legs and securing the end of the rope to the other leg just below the lashing. For handling heavy loads the number of lashing turns is increased.



Lashing for shears.

<u>Erecting Shears</u>

Holes should be dug at the points where the legs of the shears are to stand. In case of placement on rocky ground, the base for the shears should be level. The legs of the shears should be crossed and the butts placed at the edges of the holes. With a short length of rope, make two turns over the cross at the top of the shears and tie the rope together to form a sling. Be sure to have the sling bearing against the spars and <u>not</u> on the shears lashing entirely. The procedure is as follows:

1. Reeve a set of blocks and place the hook of the upper block through the sling. Secure the sling in the hook by mousing. Fasten the lower block to one of the legs near the butt, so it will be in a convenient position when the shears have been raised, but will be out of the way during erection.

2. If the shears are to be used on heavy lifts, another tackle is rigged in the back guy near its anchorage. The two guys should be secured to the top of the shears with clove hitches to legs opposite their anchorages above the lashing.

3. Several men (depending on the size of the shears) should lift the top end of the shear legs and "walk" them up by hand until the tackle on the rear guyline can take effect. After this, the shear legs can be raised into final position by hauling in on the tackle. Secure the front guyline to its anchorage before raising the shear legs and keep a slight tension on this line to control movement.

4. The legs should be kept from spreading by connecting them with rope, chain, or boards. It may be necessary, under some conditions, to anchor each leg of the shears during erection to keep the legs from sliding in the wrong direction.

L I F T I N G   D E V I C E S

A force is a push or pull. The push or pull a human can exert depends on his weight and strength. In order to move any load heavier than the maximum amount a man can move, a machine must be used to multiply the force exerted into a force capable of moving the load. The machine used may be a lever, a screw, or a tackle system. The same principle applies to all of these. If a machine is used which exerts a force 10 times greater than the force applied to it, the machine has multiplied the force input by 10. The mechanical advantage of a machine is the amount by which the machine multiplies the force applied to it in order to lift or move a load. For example, if a downward push of 10 pounds on the left end of a lever will cause the right end of the lever to raise a load weighing 100 pounds, the lever is said to have a mechanical advantage of 10.

BLOCKS AND TACKLE

A block consists essentially of a wood or metal frame containing one or more rotating pulleys called sheaves. A tackle is an assembly of ropes and blocks used to multiply force. The number of times the force is multiplied is the mechanical advantage of the tackle. To make up a tackle system, the blocks to be used are laid out and the rope is reeved (threaded) through the blocks. A simple tackle is one or more blocks reeved with a single rope. Compound tackle is two or more blocks reeved with more than one rope. Every tackle system contains a fixed block attached to some solid support, and may have a traveling block attached to the load. The single rope leaving the tackle system is called the fall line. The pulling force is applied to the fall line, which may be led through a leading block. This is an additional block used to change the direction of pull

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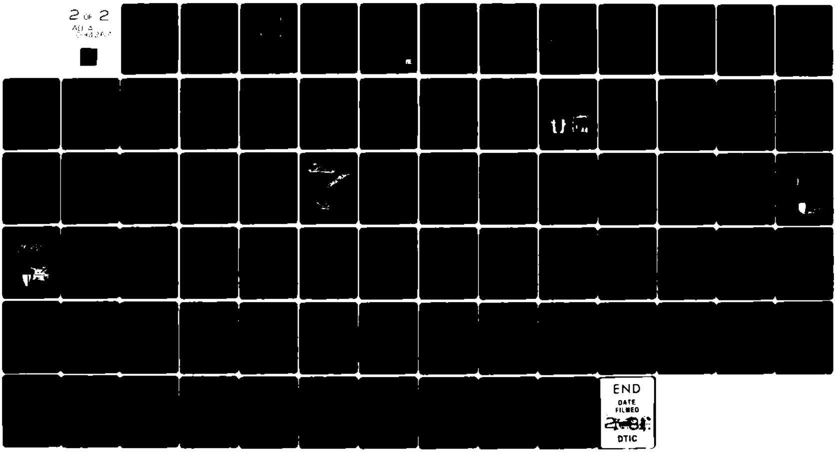
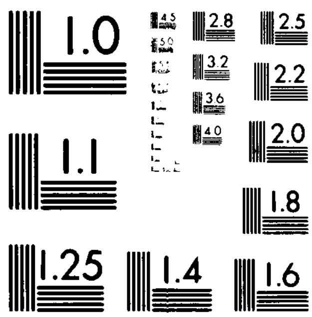




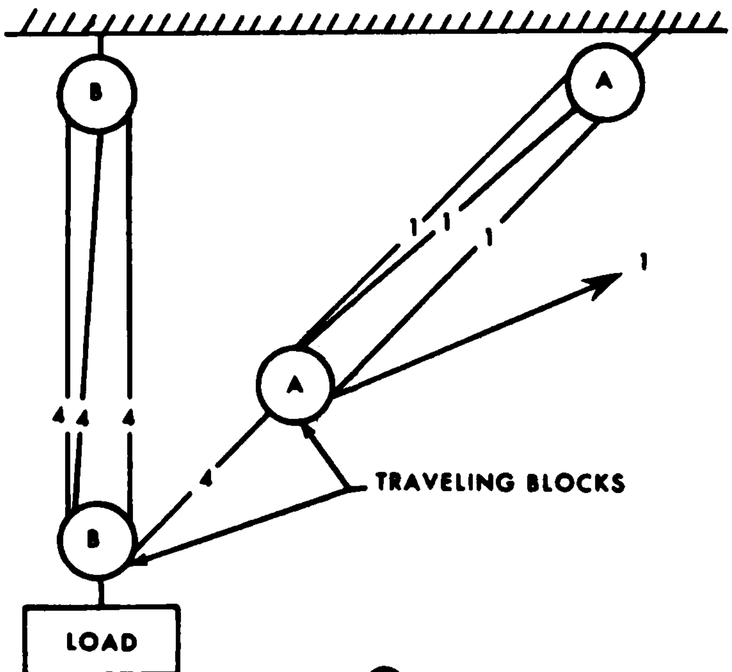
MICROCOPY RESOLUTION TEST CHART

Determining Mechanical Advantage

The ratio of the resulting total force acting on the load or traveling block to the original unit force exerted on the fall line is the theoretical mechanical advantage of the compound system. A simple method is to determine the mechanical advantage of each simple system in the compound system and multiply these together to obtain the total mechanical advantage.

Examples:

Method 1 - Unit Force. A unit force of 1 on the fall line results in 4 unit forces acting on the traveling block of tackle system A. Transferring the unit force of 4 into the fall line of simple system B results in a total of 16 unit forces (4 lines with 4 units of force in each) acting on the traviling block of tackle system B. The ratio of 16 unit forces on the traveling block carrying the load to a 1 unit force on the fall line gives a theoretical mechanical advantage of 16:1.



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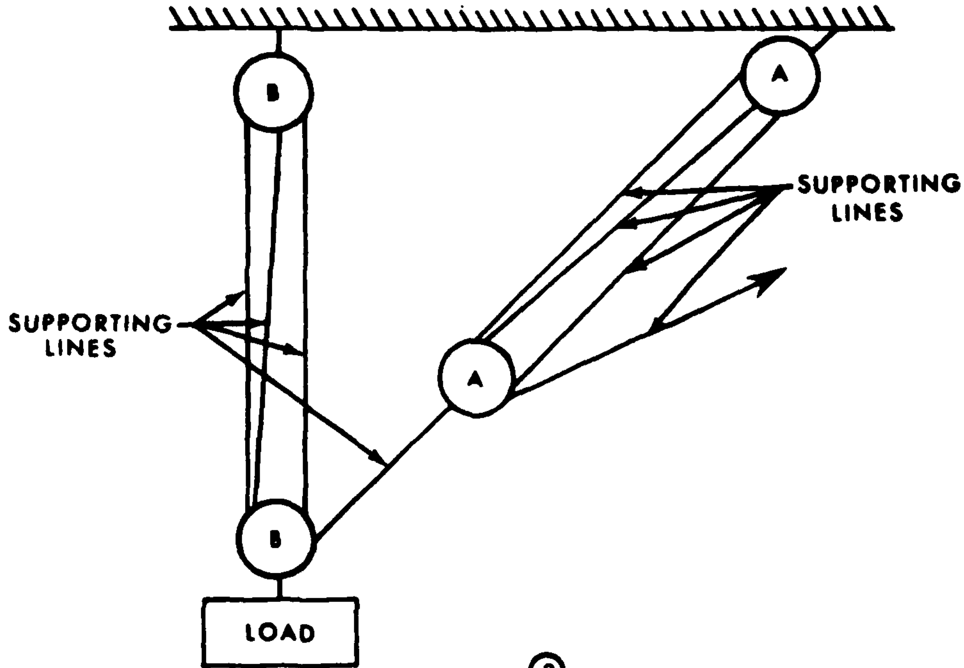
Method 2 - Multiplying Mechanical Advantages of Simple Systems. The number of lines supporting the traveling blocks in both systems A and B is equal to 4. The mechanical advantage of each simple system is therefore equal to 4:1. The mechanical advantage of the compound system is then determined by multiplying together the mechanical advantage of each simple system for a resulting mechanical advantage of 16:1.



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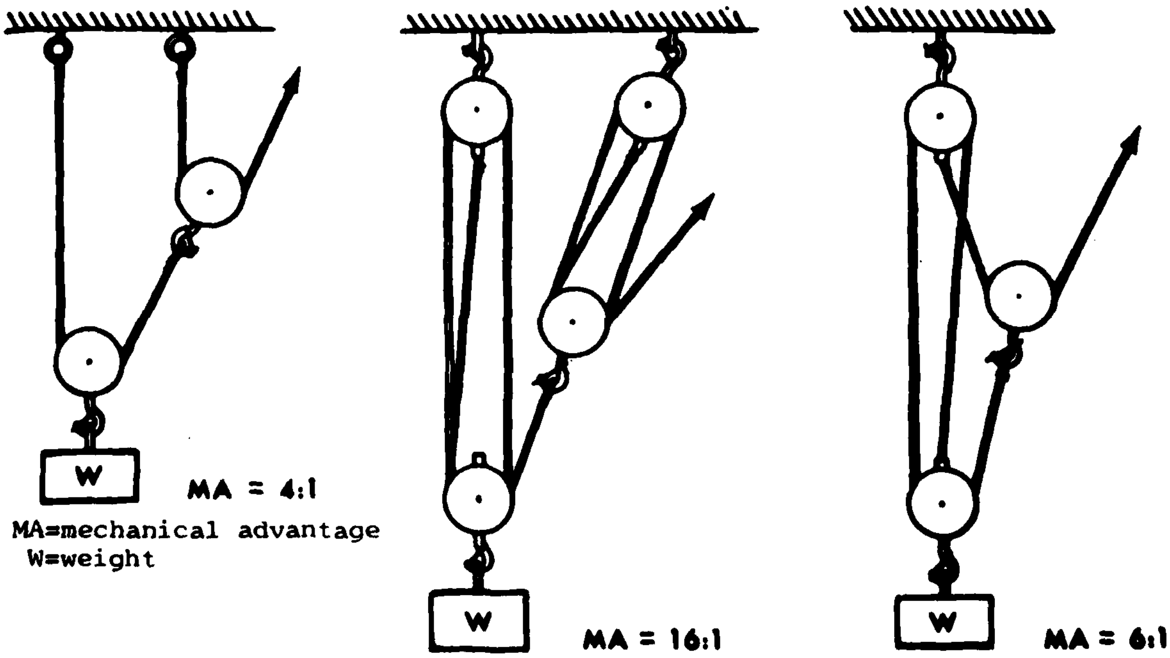
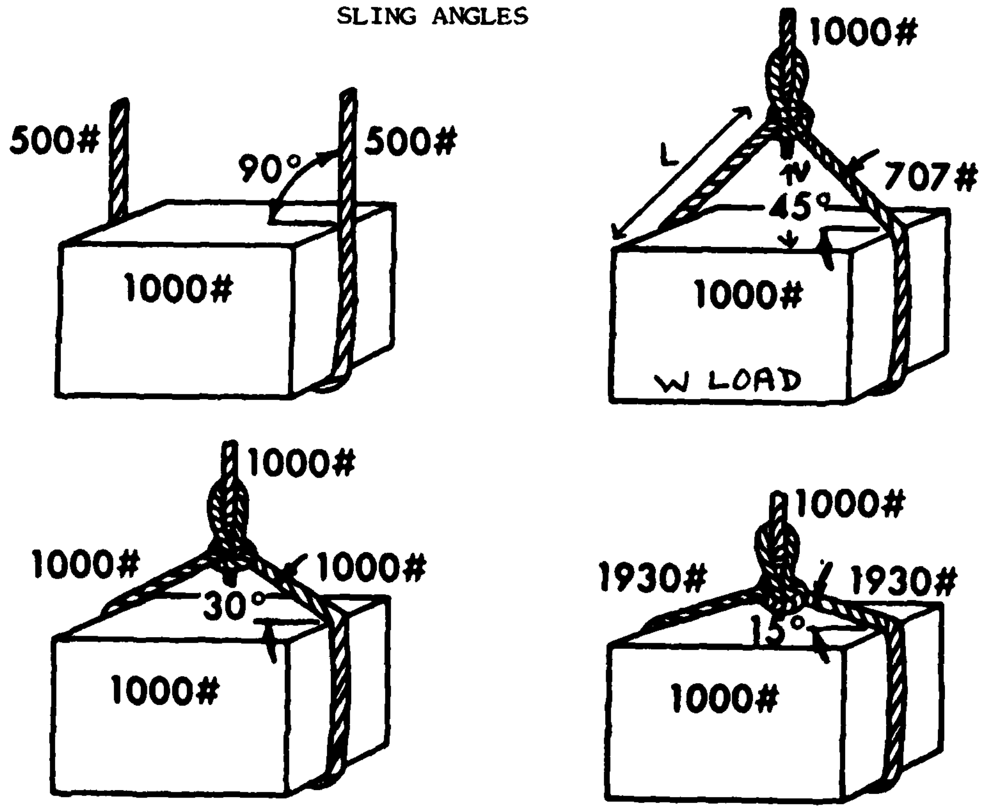


MA=mechanical advantage
W=weight

SLING ANGLES



(1) **Critical Angle—** The sling angle that exists when the tension in the sling leg <u>equals</u> the weight of the load.

(2) **Critical Angle Formula:**

$$CA = \frac{60°}{N}$$

N = Number of Sling legs

Tension in a sling leg

$$T = \frac{W_L}{N} \times \frac{L}{V}$$

T = Tension in a single leg

W_L = Weight of load

N = Number of sling legs

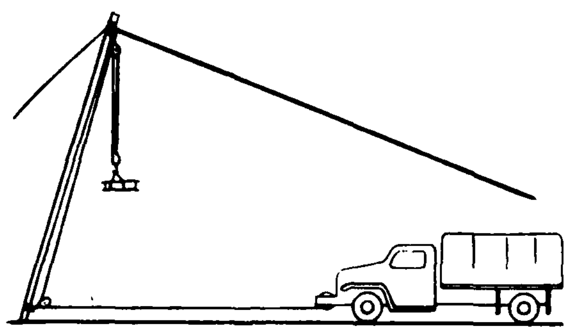
L = Length of sling leg

V = Vertical distance of sling

Computing tension in a sling.

WINCHES

Vehicular-mounted winches and engine-driven winches are used with tackles for hoisting. There are two points to consider when placing a power-driven winch to operate hoisting equipment: first, the angle with the ground which the hoisting line makes at the drum of the hoist; and second, the fleet angle of the hoisting line winding on the drum. The distance from the drum to the first sheave of the system is the controlling factor in the fleet angle. When using vehicular-mounted winches, the vehicle should be placed in a position which permits the operator to watch the load being hoisted. A winch is most effective when the pull is exerted on the bare drum of the winch. When a winch is rated at a capacity, that rating applies only as the first layer of cable is wound onto the drum. The winch capacity is reduced as each layer of cable is wound onto the drum because of the change in leverage resulting from the increased diameter of the drum. The capacity of the winch may be reduced by as much as 50% when the last layer is being wound onto the drum.



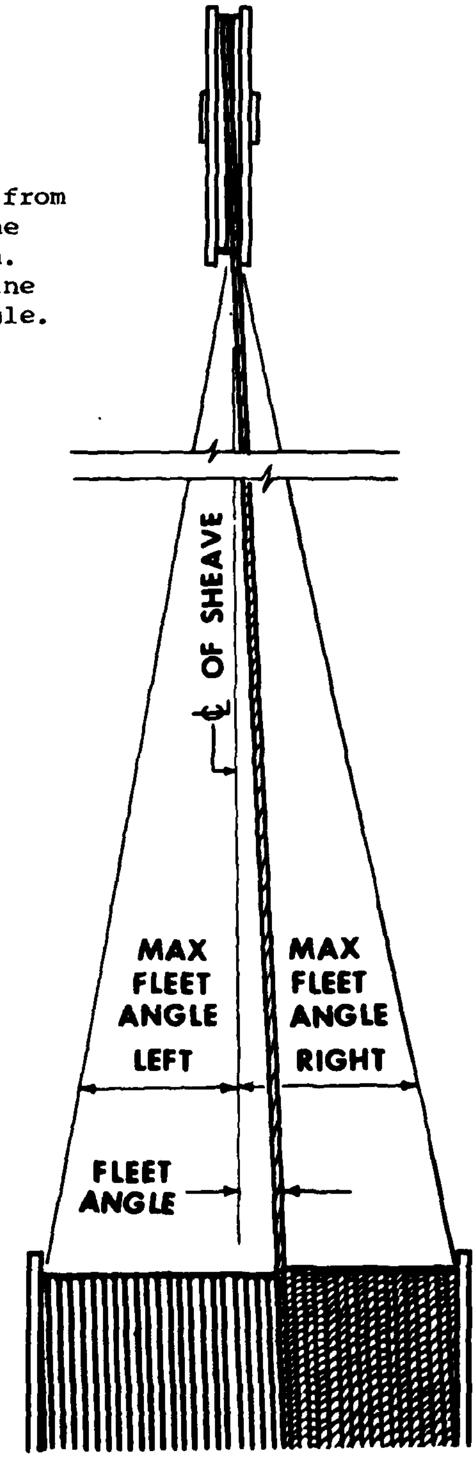
Using a vehicular winch for hoisting.

Ground Angle

If the hoisting line leaves the drum at an angle upward from the ground, the resulting pull on the winch will tend to lift it clear of the ground. In this case a leading block must be placed in the system at some distance from the drum to change the direction of the hoisting line to a horizontal or downward pull. The hoisting line should be overwound or underwound on the drum as may be necessary to avoid a reverse bend.

Fleet Angle

The drum of the winch is placed so that a line from the last block passing through the center of the drum is at right angles to the axis of the drum. The angle between this line and the hoisting line as it winds on the drum is called the fleet angle.



PART THREE

RESCUE TOOLS

Use of tools, equipment and materials should not be limited by the scope of application experienced in this manual.

Consideration must be given for use of equipment, materials, and tools in substitution of those utilized for specific application in this manual. Materials, tools, and other resources found at the incident scene must often be employed to achieve the goal of rescue.

Complete and thorough training in use of tools as well as continuing skill level maintenance training is essential.

Necessity is the mother of invention -- improvisation is necessary for effective rescue.

CRIBBING

During rescue operations, any time a load is lifted a method for temporary support is needed to insure the safety of the rescuer and of the trapped persons. One quick and simple method of temporary support is known as CRIBBING.

Cribbing is the construction of a stable platform utilizing wooden blocks. Ideally, the blocks for cribbing are usually made from construction grade framing lumber and are two sizes -- 2" x 4" x 18" and 4" x 4" x 18". However, at the scene of a disaster, there is usually ample material available for making temporary cribbing. Any material with a hard, flat surface can be utilized. The requirements for improvised cribbing are (1) the material must be flat on both surfaces; and (2) the material must be able to withstand the weight it will have to support. Furniture, bricks, concrete blocks, and tire rims are all acceptable alternatives to pre-cut wooden blocks.

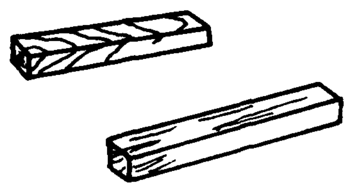
Cribbing provides the safety necessary when a load is being lifted by preventing the load from falling due to tool failure or slippage. As the load is raised, the crib should be built up accordingly. No rescue personnel should be allowed under a raised or unstable load without the proper safety precautions -- cribbing.

There are two basic methods of constructing cribs -- the Crosstie Crib and the Box Crib.

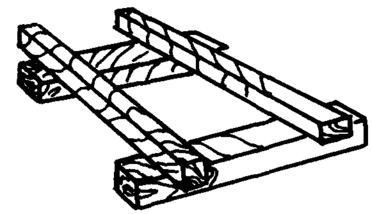
Cribbing allows the rescuer to utilize rescue tools more efficiently. If mechanical jacks, hydraulic rams, etc., must be reset, the load can be cribbed and the lifting tools reset. By utilizing cribbing, tools can also be freed for other uses.

An effective method of building a fulcrum during prying operations is to use cribbing techniques to increase the height of the fulcrum.

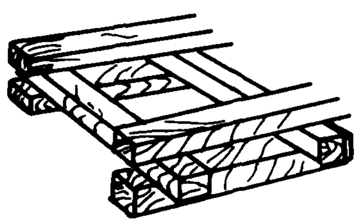
Crosstie Box



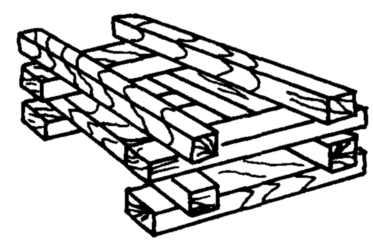
1st STEP



2nd STEP



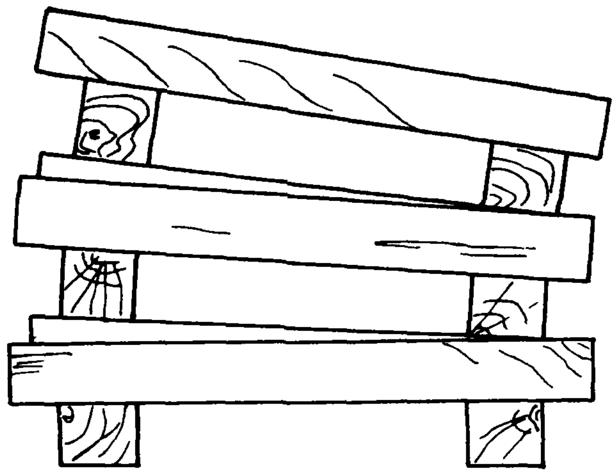
3rd STEP



4th STEP

CRIBBING

Use of wedges with cribbing.

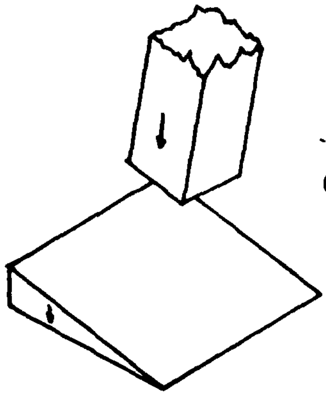


Always Crib near Jacks

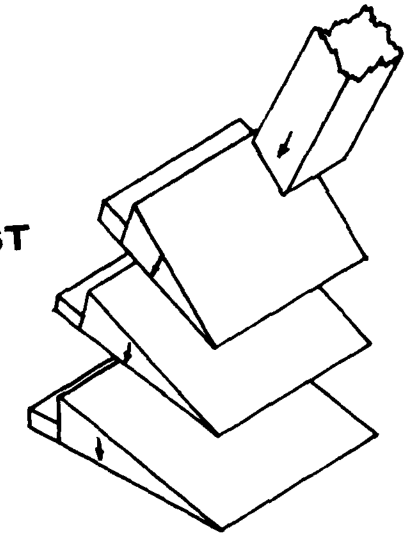
1. For safety
2. To hold load while shifting or raising jacks.
3. To allow complete removal of jacks.

Wedges (4"x4"x12") cut diagonally, are used to "snug-up" or tighten a load supported by cribbing. Wedges are also used to change the angle of weight thrust. Wedges are needed in tunneling, shoring and strutting operations.

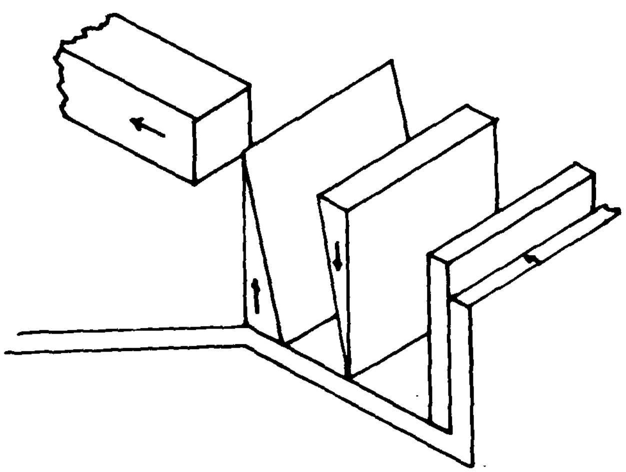
USE OF WEDGES



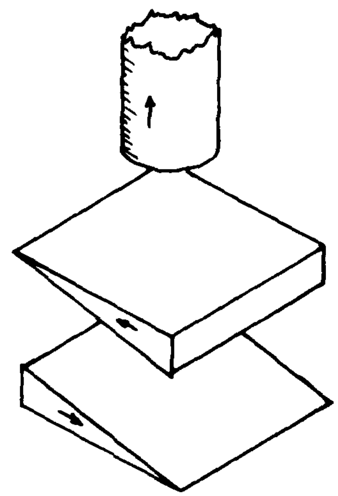
CHANGE THE ANGLE OF THRUST



1. Size to fit the job
2. Medium hard wood
3. Smoothly sawn finish—No sanding
4. No paint or varnish (penetrating stain or wood preservative O.K.)



SNUG UP LOAD



CUTTING TOOLS

Rescue personnel may encounter many different types of rescue situations where cutting is necessary. The type of material to be cut will depend upon the type of building construction or the construction of the vehicles involved in the rescue situation. This material can include heavy and/or light wood or metal, reinforced concrete, pipe, masonry and wire cable.

Cutting tools which can be used for rescue operations include:

- Hand powered tools - saws, picks, bolt cutters, pipe cutters, wire cutters.
- Pneumatic powered tools - chisels, saws, jack hammers or pavement breakers.
- Electric powered - saws, jack hammers, chain saws.
- Gasoline engine powered - rotary saws, chain saws, jack hammers.
- Hydraulic cutters - gasoline engine or hand powered.
- Oxygen/Acetylene torch.

When a rescue situation is encountered which requires the use of cutting tools, the following considerations must be taken into account:

- The atmosphere. Is the atmosphere flammable? Is the area vented so smoke from the cutting operation will not hinder further rescue efforts?
- Vibration. Will vibrations from the use of cutting tools cause further collapse or injury to the victim? What effect will the noise have upon the trapped victim?
- Fire - Are sparks a problem? Do you have the proper support equipment in event of a fire?
- The effect of the cutting operation. Is the material to be cut under load? What will happen to both ends of the material when the cutting is complete? Will this cut further weaken the structure?

Metal has a "memory." Metal wants to return to the shape in which it was formed. This memory causes metal to spring back or change position when it is freed of a load.

Safety must be a first consideration in cutting operations. When cutting a section out of a piece of pipe or other material, using hydraulic or bolt cutters, a free end can be dangerous. These type cutters place a great amount of force on the material being cut. When the material is severed, a free end can be propelled with a great amount of force.

Besides the tools available on a rescue unit or from the fire department, cutting tools are available from a variety of different sources. Some sources which may be utilized as a resource for cutting tools are:

- Schools with vocational education programs - hand and power saws, oxygen/acetylene torch.
- Repair garages - pneumatic chisels and saws, oxygen/acetylene torch, electric powered cutting tools.
- Utility companies - pneumatic jack hammers, bolt and cable cutters, gasoline powered rotary saws for wood or concrete.
- Manufacturing companies - electric and pneumantic powered cutting tools, hydraulic powered cutting tools, oxygen/acetylene torch.
- Construction companies - hand and power saws, bolt and cable cutters, oxygen/acetylene torch.
- Equipment rental yards.

By proper size-up or assessment of the situation, the proper tool can be selected and the cutting operation performed safely.

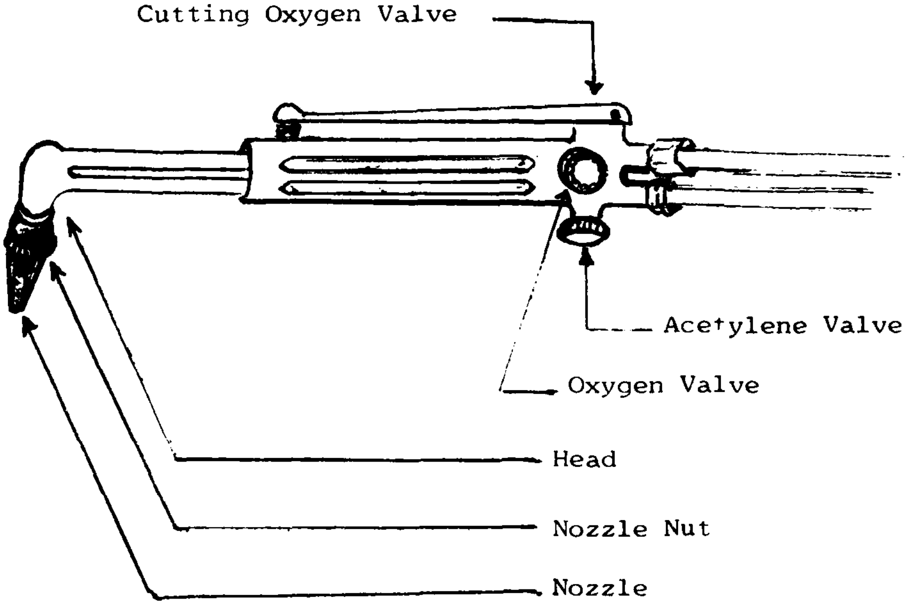
OXYGEN/ACETYLENE CUTTING TORCH

Until approximately 15 years ago, the oxygen/acetylene cutting torch was the only metal cutting tool available to the rescuer. Today there are many metal cutting tools which are easier and safer to use during rescue work. Although other tools have predominantly taken the place of the oxygen-acetylene torch, it still has a place in rescuing persons trapped as a result of structural collapse, industrial accidents, earthquakes, and even transportation accidents.

Oxygen/acetylene cutting torches can be found on fire and rescue apparatus, at welding shops, garages, muffler repair shops, fire departments, and other places too numerous to name. All fire service and rescue agencies should have a listing of where portable cutting torches could be obtained if the need for them should arise.

During heavy rescue work the cutting torch can be very useful for cutting steel reinforcing bars in broken concrete, pipes in collapsed structures, heavy steel beams, anchor bolts for heavy equipment, and any metal where the fire hazard is controlled; or where the use of the fire torch will free other cutting tools for use in victim areas or where a high fire hazard exists.

OXYGEN-ACETYLENE CUTTING TORCH



PNEUMATIC TOOLS

Pneumatic (air) powered tools are used extensively during rescue operations. Air may be supplied by engine-driven compressors or cylinders. Many commercial and/or industrial facilities have air available. Air tools usually require approximately 100 psi air pressure for effective operations.

Air tools are non-spark producing. However, the bits, cutting tools, drills, blades, etc., will produce sparks or heat of sufficient intensity to be an ignition source.

Examples of common air tools readily available for use in physical rescues include:

- Jack Hammer
- Drills
- Saws - rotary, blade
- Chisels
- Impact - wrench, nail drivers, etc.

JACK HAMMERS

Jack hammers are impact tools used for breaking, drilling, breaching, digging, and compacting almost any material except steel. The use of this tool for heavy rescue of trapped victims is extremely valuable if used properly. However, being an impact tool, you must take into consideration the vibrations emitted from the tool and be aware of adverse conditions that could be created.

Other problems inherent in the tool are:

- Noise
- Driving force exhaust.
- Sparking from the "gad."*

*(Gad - a chisel or pointed iron or steel bar for loosening rock. These are the bits that actually contact the surface being worked on.)

For general use in rescue work, jack hammers range in weight from 5 to 90 pounds. There are, of course, large truck and tractor-mounted units. The jack hammer has three sources of power:

- Pneumatic (air).
- Electricity.
- Water.

The most commonly used is pneumatic and requires large capacity compressors with high pressure hoses. There is a wide assortment of "gads" available to assist in many rescue operations whether underground, ground level, or above ground.

Jack hammers are universally owned and used by virtually every contractor, utility company, public works agency, and equipment rental yard.

AIR CHISEL

The air chisel is a pneumatic powered tool that is fully portable and adaptable to many different types of rescue work. The air chisel can be used for cutting sheet metal, copper, aluminum, plastic, brass, wood, plywood, and hard fiber or wall board. It can be used for forcible entry, cutting metal door and window casings, ventilation, and in digging and tunneling operations.

The air chisel is designed to operate between 100-150 psi, with 120 psi being the normal pressure. The air chisel can be operated with any air supply that can provide the proper pressure at approximately 4-5 cubic feet of air per minute. Acceptable sources of air are bottles of compressed air, air compressors, and air brake systems. The air chisel should be operated with compressed air only; NEVER with oxygen.

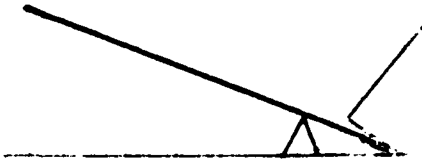
Besides cutting and digging, the air chisel, with different tools, can be used for many jobs during rescue operations. The shank of the tools for the air tools is a .401 Parker taper. Any tool with this taper can be used in the air chisel. One example is utilizing the flat headed tools for auto body work, for driving spikes when engaged in shoring and stabilizing operations.

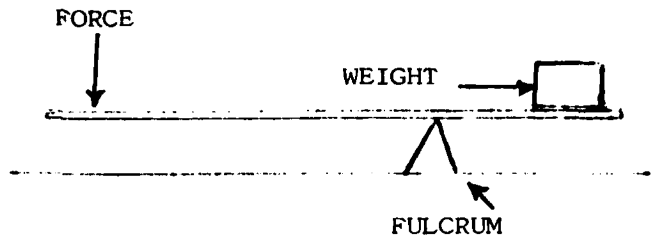
PRYING TOOLS

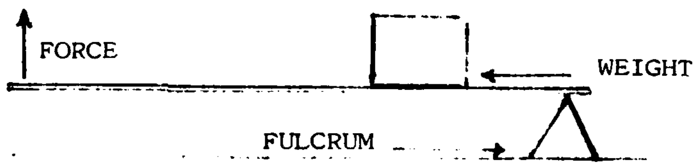
All prying tools are based on the principle of the lever. The lever is the least complicated and simplest lifting device used in rescue work. A lever consists of a rigid, straight or curved bar which is free to move about a fixed point called a fulcrum. Rescue personnel will use levers of various lengths and of several types. Other than commercial tools, timbers, pieces of pipe and other items found at the scene of a disaster can be used as levers.

The force which must be exerted on a bar to lift a load (the mechanical advantage) depends on the ratio of the distance from the end of the bar to the fulcrum, compared to the distance of the load from the fulcrum. For example, if a person applies force on a bar 10 feet from the load and the fulcrum is 1 foot from the load, a 9-to-1 mechanical advantage is gained. The mechanical advantage is increased or decreased as the pivot/fulcrum is moved toward or away from the load.

The pivot or fulcrum must be of material that will not slip or crumble. Wood placed between a metal bar and a metal beam will prevent the beam from slipping on the bar. The fulcrum can be raised by the use of cribbing. Loads should be cribbed as they are raised to prevent the load from falling.







HYDRAULIC TOOLS

Hydraulic powered tools can be used extensively in rescue operations. These operations include rescue problems which involve cutting, lifting, digging, pushing and pulling, etc. Excluding hydraulic tools designated as rescue tools, hydraulic tools are available from a number of sources which include:

- Automotive repair garages - jacks, rams, spreaders.
- Metal fabrication - cutting and forming tools
- Underground construction - rams, spreaders.
- Utilities - hose and pipe clamp, spreaders, cutters, jacks.
- Manufacturing - cutters, spreaders, jacks and rams.
- Rental agencies - all types.
- Vocational schools - all types.

A survey of your local area may develop many sources of tools adaptable to rescue situations. The time for identifying these resources and gaining the proficiency needed to fully utilize them safely in a rescue situation is before the incident occurs.

HYDRAULIC RESCUE EQUIPMENT

Hydraulic rescue equipment consists of a hydraulic pump which supplies hydraulic pressure to a hydraulic ram. Attachments to the ram enable rescue personnel to utilize this equipment for lifting, spreading, pulling, stabilizing or bracing operations. The hydraulic pumps are either hand operated or power driven. When utilizing hydraulic equipment, the limiting factor which must be considered is the capacity of the pump, the ram, and the accessories.

Hand operated hydraulic rescue equipment comes in three basic sizes with a normal capacity of 4 tons, 10 tons, and 20 tons. To calculate the capacity of this equipment, the pressure generated by the pump is multiplied by the area of the piston of the ram. All common makes of hand operated pumps and rams operate at about the same 9,000 psi to 10,000 psi, and all are rated depending upon the area of the ram itself. For example, a 10 ton unit has a ram with an area of approximately 2.1 sq. in. Multiplying the pressure generated by the pump (9,500 psi) by the area of the ram (2.1 sq. in.) equals approximately 20,000 pounds, or a 10 ton unit.

With a given size pump, the usual limitation on the size of the ram which can be used is not the pressure but the amount of oil in the pump reservoir. The amount of oil required by a particular ram is equal to the ram travel, or how far the ram fully extends, times the area of the ram base. For a 10 ton unit with a 2.1 sq. in. base and a ram travel of 10 inches, multiplying 2.1 sq. in. times 10 in. equals 21 cubic inches. Therefore, 21 cubic inches of hydraulic oil is required to extend a 10 ton ram 10 inches.

The various attachments, extensions, pipes and threaded collars which attach to the ram decrease the capacity of the ram. When using extensions, the capacity of the ram is decreased 25%. Further decrease the capacity of the ram 10% for every foot of extension. The maximum length of extensions should be five feet.

Chain pulling attachments are limited to not more than a 1200 pound capacity for the 4-ton unit and 2400 pounds for the 10-ton unit. It is extremely important for rescue personnel to know the limitations of their hydraulic equipment. Overloading can cause tool failure.

Motor driven hydraulic equipment has specifications which are set by the manufacturer. At no time should these specifications be exceeded. The pressure on motor driven hydraulic units is preset by relief valves. When the tool containing the ram is overloaded, it will not continue to operate. With all hydraulic equipment, it is extremely important that the specifications of the manufacturer be followed as to the type of oil used. Using the improper hydraulic oil can cause the "O" ring seals to swell and seals to leak, causing tool failure.

The hydraulic rescue tool has been carefully engineered and manufactured to give trouble-free service for many years. They require a minimum of care and stand up under a maximum of heavy usage. Following are some do's and dont's for using hydraulic rescue tools:

DO'S

- Protect the threads on ram cylinder. Protect the piston by keeping ram cap screwed on when not using other attachments.

- Keep oil lines clean. Use every precaution to guard unit against entrance of dirt or other foreign matter which might cause pump failure.

- Use only recommended hydraulic fluid. Never use brake fluid or ordinary cylinder oil.

- Provide sufficient clearance. See that hose is clear when ram extends. Avoid wear on hose by keeping it free from obstructions.

- Keep unit away from fire and excessive heat as this will tend to melt sizing in caps and cause leakage. Heat also weakens the hose structure.

- Treat the hydraulic rescue tool as you would any other piece of fine machinery.

DONT'S

- Attempt to disassemble the pump and ram units yourself.

- Use a dirty oil can or one that previously contained any other fluid when filling the ram.

- Fill pump beyond oil level or neglect to do a complete bleeding operation.

- Overload the ram. Never try to lift a load which exceeds the ram capacity as it will cause cracked cylinders, blown cups and bent piston.

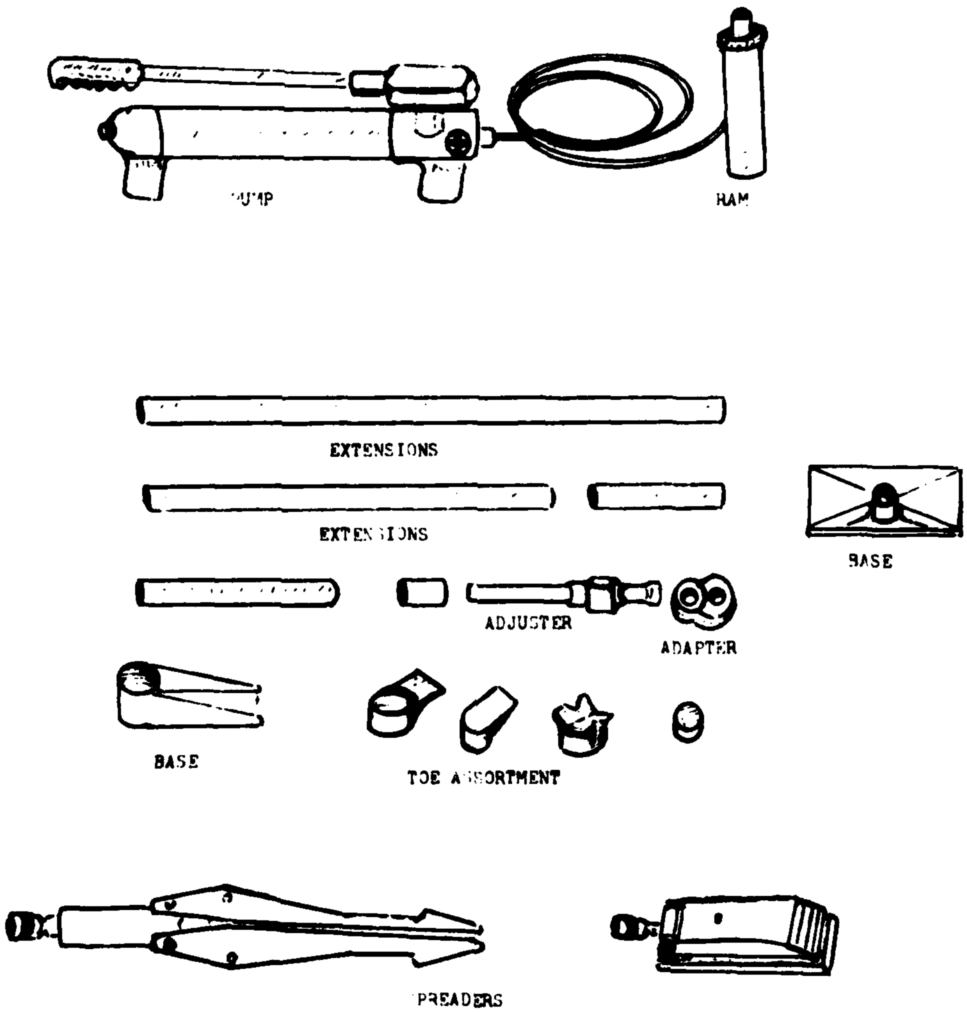
- Over-extend ram. There is a tremendous force in hydraulic power and it is possible to push piston out of top of ram.

- Pump rapidly when load is off center such as when you are using pressing, pulling and spreading operations or lifting with Spreading Toes. Excessive off-center loads produce strain on ram piston and tubes.

- Drop heavy objects on hose. It will weaken hose and cause it to leak or burst.

- Carry unit by hose. This puts undue strain on hose.

HYDRAULIC RESCUE TOOL



LIFTING TOOLS

Some incidents may require tools and appliances to lift vehicles, equipment and debris, etc., to gain entry and/or remove victims to safety. Safety is a prime consideration when lifting is required. Rescuers must be familiar with various types of tools and appliances which are available either at the scene or in the area. They must be familiar with the operation of these devices and the limitations, and safety precautions which must be followed. This should be done during training exercises on a continuous basis.

Some tools used for lifting include ropes-pulleys, winches, "A" frames, crow bars, pry bars, jacks (mechanical and hydraulic), air bag systems, cranes, tow trucks, etc. This equipment is available from various sources including fire services, local, city, county, state and federal government as well as rental agencies, contractors, dealers and equipment agencies.

AIR BAG SYSTEMS

In recent years, steel reinforced rubber, inflatable bladders, commonly referred to as air bags, have been introduced to the rescue tool field. Like all other rescue tools, the physical capacity of the tool and the imagination of the rescuer are the only limitations for using air bags during rescue work. Basically air bags are used for lifting heavy loads, bending steel beams and bars, moving heavy loads, disassembling vehicles and machinery components, and stabilizing unstable loads. With the knowledge of how the bags operate and limitations of the bags, the rescuer can adapt their use to almost any rescue involving trapped victims.

General Specifications

Most air bag systems consist of the following components:

- Inflatable rubber bladders (minimum of two; maximum of 8).
- Air hose (normally three lengths).
- Air Pressure Regulator (one).
- Air Control Valve/Safety Valve assembly (one).
- Compressed Air Cylinders (one).
- Hand and Foot Air Pumps, adapters for using alternate air supplies, and special harnesses or equipment used for opening doors are frequently included in the systems.

Operating Characteristics

Air bags operate without flames, grinding, motors, sparks or mechanical cutting. Compressed air is used as the moving force -- requires maximum of 87 psi internal air pressure. They are completely portable and require only one man to operate. Can be operated on any soft, smooth, or uneven surface or at any altitude. Are capable of lifting in excess of 100,000 pounds.

Availability of Air Bag Systems

1. Fire Departments
2. OES Fire and Rescue Combination Engine.
3. Airport facilities handling aircraft recovery missions.
4. Some 4-wheel-drive or dune buggy enthusiasts.

Alternate Air Sources

1. Compressed air cylinders.
2. Vehicle air brake systems.
3. Street rapair air compressors.
4. Air compressors on mobile construction, lubrication, and maintenance equipment.

The above-listed locations of air bag systems and alternate air sources are just a sample, and not intended to be a complete listing of availability. Persons charged with the responsibility of performing heavy rescue should pre-plan for the need of air bag systems and locate all available resources in their area. The rescuer should also have access to the adapters necessary for utilizing any air source in their particular area.

Any air source used must meet the following criteria:

- Must supply enough volume to fill the bag.
- Must be capable of supplying air at 87 psi minimum.
- You must have adapters suitable for connecting the air source to the air bag regulator or control/safety valve assembly.

Uses for Air Bag Systems

- Lifting heavy machinery (industrial, farm, electrical, etc.).
- Lifting heavy building components (masonry slabs, steel beams, etc.).
- Vehicle rescue (windshield removal, lifting steering columns, moving seats, etc.).
- Spreading (steel beams, bars, etc.).
- Floats (during water rescues).
- Lifting trees, poles and beams.

MECHANICAL JACKS

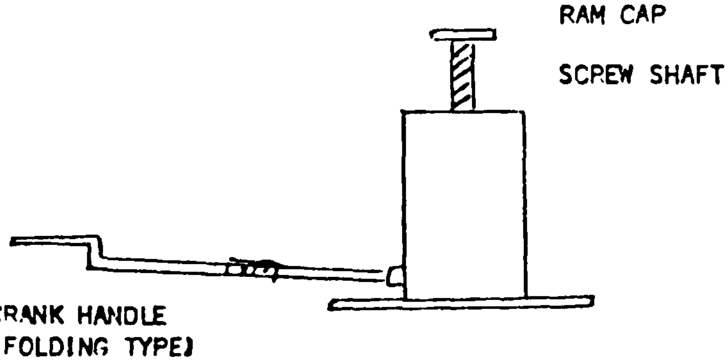
With the many different types of mechanical jacks available, only the Screw, Ratchet and High Lift or Handy Man types are suited for heavy rescue work.

SCREW JACKS - Operating Characteristics and Availability

This jack is operated by turning a crank handle which in turn rotates a worm gear causing the threaded shaft of the jack to extend or retract, depending upon the direction of handle rotation.

Screw jacks are normally in the 3/4-ton to 2-ton range and are most commonly found on light trucks or in automotive repair facilities. The uses for this type jack are identical to the hydraulic type jack.

TYPICAL SCREW JACK

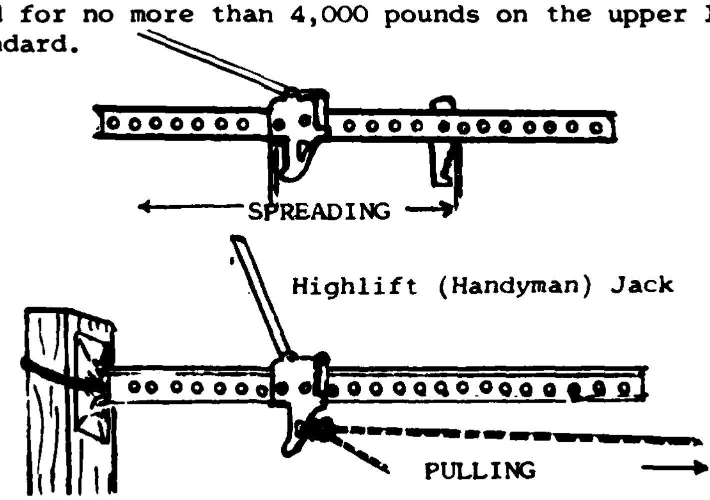


RATCHET-TYPE JACKS

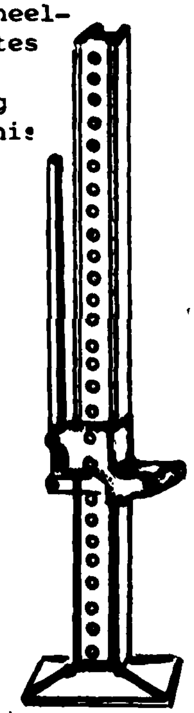
The most common of the ratchet type jacks are the automotive bumper jacks. Although this jack is very unstable and limited in it's load lifting capacity, it is very useful for stabilizing vehicles and for displacing or distorting vehicle components.

The most useful ratchet-type jack is the Handy Man or High Lift jack. These jacks are known by many names depending on what part of the country you are in or from. Farmers Jack, Lumbermans Jack and Four Wheelers Jack are just a few of the many different names for this type jack.

This type jack is most often found in the rural areas or on four-wheel-drive vehicles and some rescue vehicles. The high lift jack operates on the ratchet principle, moving two climbing pins. The climbing pins alternately move and hold the load during lifting and lowering movements, positively holding the load as the jack is operated. This type jack is rated at 7,000 pounds; however, with the extension in place, is warranted for no more than 4,000 pounds on the upper 1/3 of the upright standard.



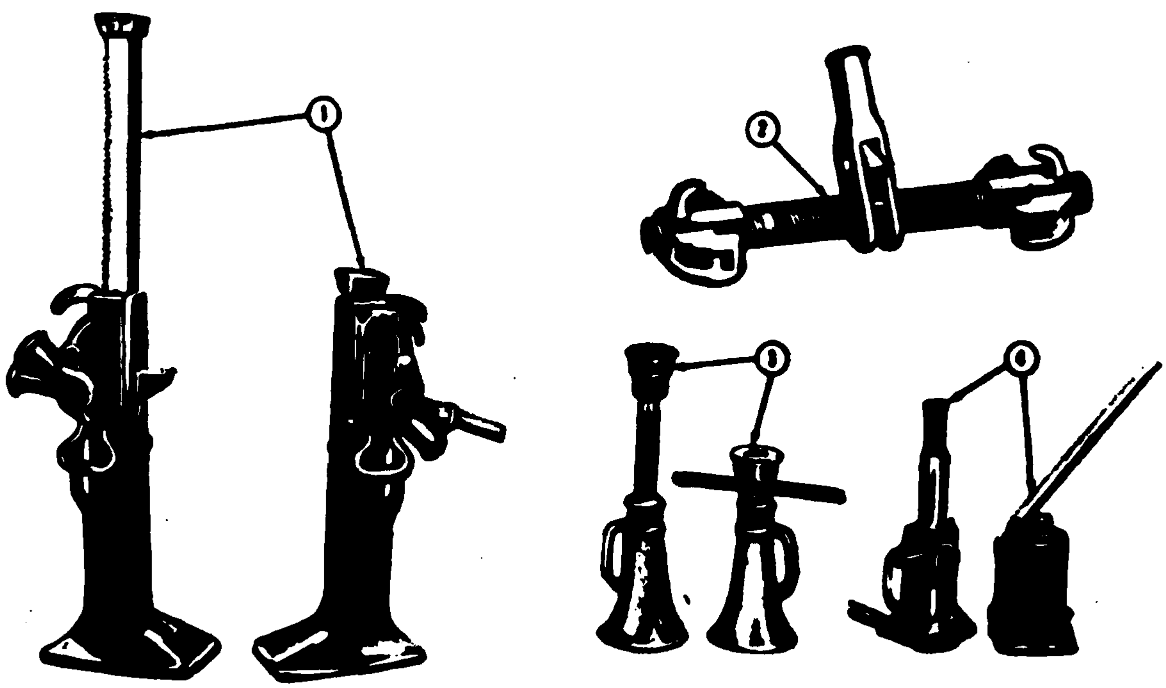
Highlift (Handyman) Jack



HYDRAULIC AND MECHANICAL JACKS

Jacks are portable machines capable of exerting great pressure or lifting heavy loads a small distance. During heavy rescue work, jacks can be very useful for spreading, lifting, supporting or stabilizing heavy loads. Due to the variations of compactness and design of jacks, they are sometimes easier to use in close quarters than pry bars or power tools. The jacks most widely used for rescue are the 1½-ton to 20-ton hydraulic and the 1½-ton to 3½-ton mechanical types. There are several general safety factors which apply to all types of jacks.

- Jacks should be placed at a 90 degree angle to the load.
- Jacks should have a capacity higher than the weight of the load.
- Jacks should be placed on solid, flat surfaces.
- Jacks should not be used as the only support for a load.
- Any load being moved by a jack should be cribbed as the jack extends.
- Always remove the jack handle when it is not in use.



1 Ratchet lever jack with foot lift **2 Steamboat ratchet** **3 Screw jack** **4 Hydraulic jack**

Mechanical and hydraulic jacks.

LADDERS IN SPECIALIZED RESCUE

Fire service ladders provide many uses in carrying out rescue procedures. Besides being used to gain access to upper or lower stories and roofs, ladders can be used as bridges, derricks, stretchers and as a means for lowering victims.

Bridging Gaps

If spaces between buildings or areas of damaged floors or roofs have to be bridged, ladders can be utilized. Ladders can also be used to build a suspension bridge. Boards or planks should be placed on the rungs of the ladder to give additional strength and to make passage over the ladder easier.

Ladder Slide

The ladder slide can be employed to remove victims from upper stories when a ladder of sufficient height is available. This method also is good to use when manpower is limited.

Pry bars, axe handles, or other suitable material must be placed through the "D" rings of a stretcher to allow the stretcher to slide on the beams of the ladder. The lowering line can be passed over the rungs of the ladder to form a friction brake.

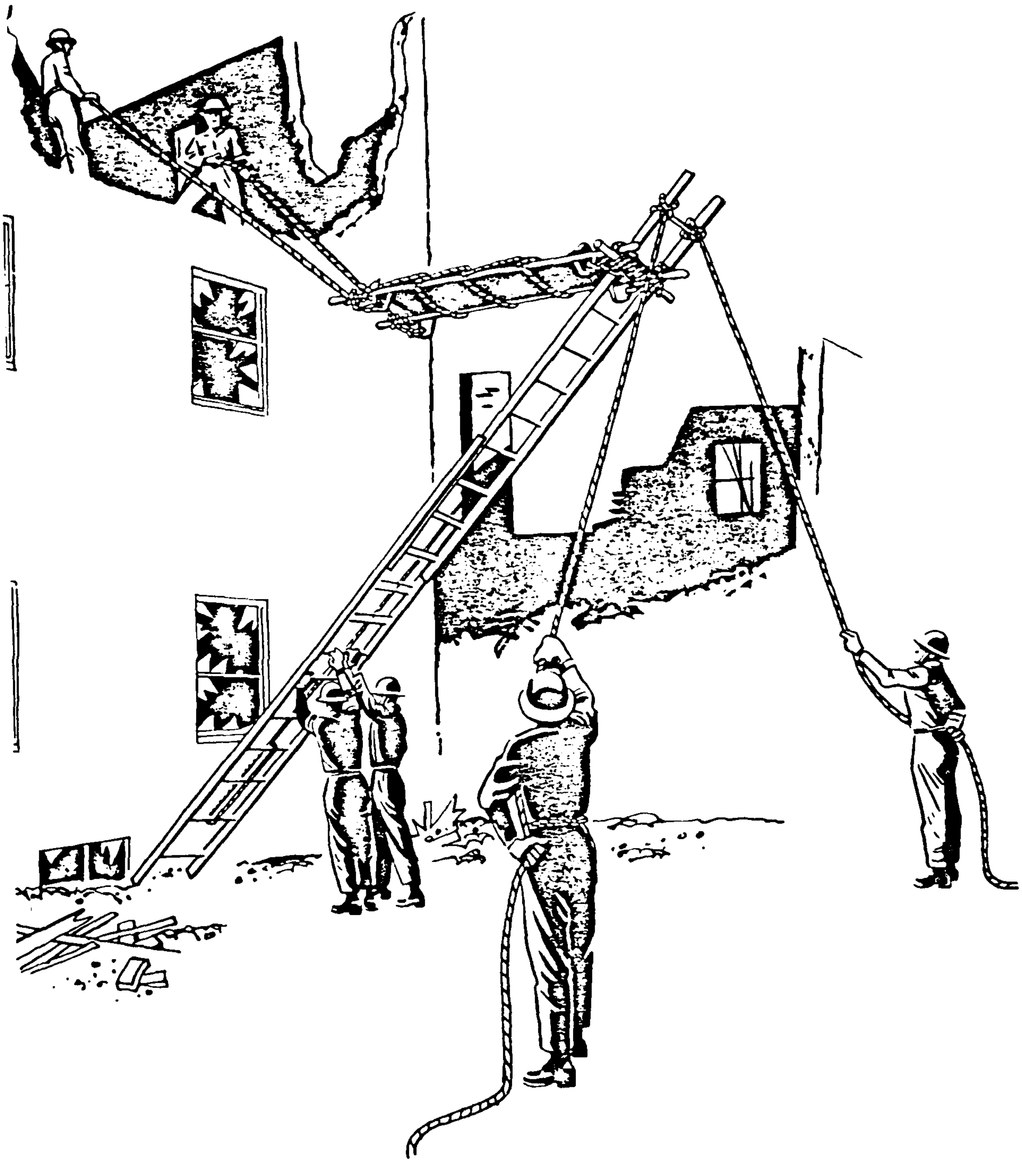
Leaning Ladder

The leaning ladder can be used to lower victims when the ladder is long enough to butt against the building above the opening to be used. An elevator is actually constructed, and a great many victims can be lowered in a short period of time using a minimum of manpower. The victims should be placed on a blanket, and the blanket then can be placed in the stokes with the victim. The stokes or stretcher should be rigged so that at least one side rigging can be removed quickly to aid in victim removal.

Ladder Hinge

The ladder hinge method of lowering victims can be employed when there are several victims that may need to be lowered or raised in a horizontal position. The ladder need only be long enough to reach the opening being used.

The ladder is placed vertically against the wall from which the victim will be lowered. The tip of the ladder should extend one to two rungs above the opening. The stokes is secured to the top of the ladder and enough slack is left in the lashing so the stokes can hinge on the ladder. If possible, the guys should be spread out at approximately a 70-degree angle.

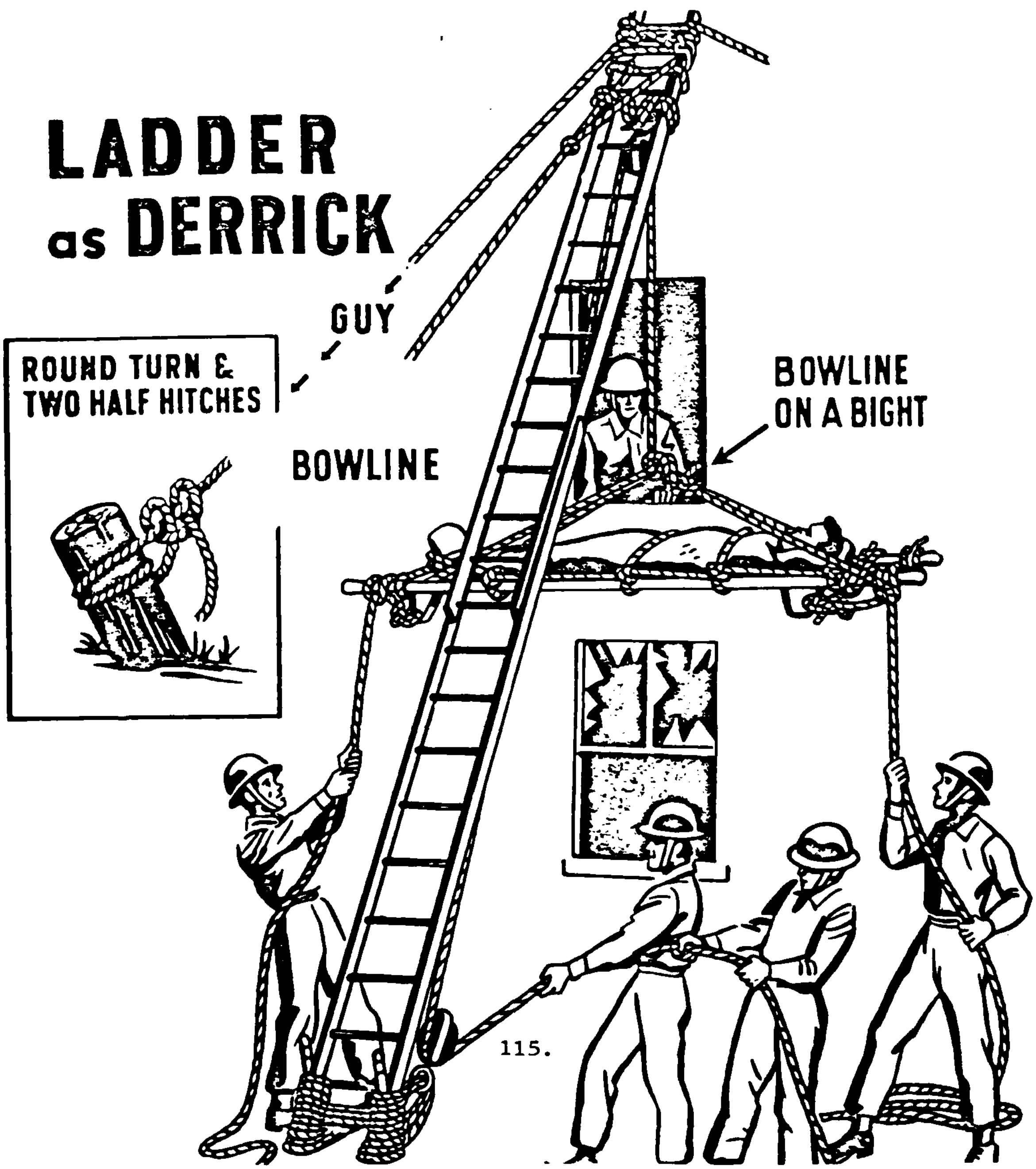


LADDER HINGE

Ladders as a Derrick

Any time a derrick would be beneficial and suitable beams are not available, ladders may be utilized. Ladders can be used in place of beams to make jib arms, "A" frames, and gin poles. The same guidelines which apply to beams apply to ladders. The shorter the ladder, the stronger it is. When lashing to a ladder, always lash to the beams. When slinging a block on a ladder, rig the sling so the force is distributed to the beams. The sling should pull the beams inward or compress the rungs. Do not hang a block off of a rung.

For long spans between the anchor point and the load point, a ladder can be reinforced utilizing ropes and additional ladders, using the principle of a suspension bridge.



BRIDGING

Transporting people, whether rescuer, evacuee, or casualty, by bridging is tedious, limited, and risky. The tedious or slow application of bridging techniques comes about by the fact that only one person at any time can use the bridge. When moving any number of people, other methods of transportation must also be considered.

Bridging is limited by the distance (span) to be bridged. Unless heavy lifting equipment is available, a span of 30 feet is the maximum that can be bridged using rigid materials. Ropes may be used to bridge longer spans.

Bridging Materials

There are four basic materials or equipment used for bridging:

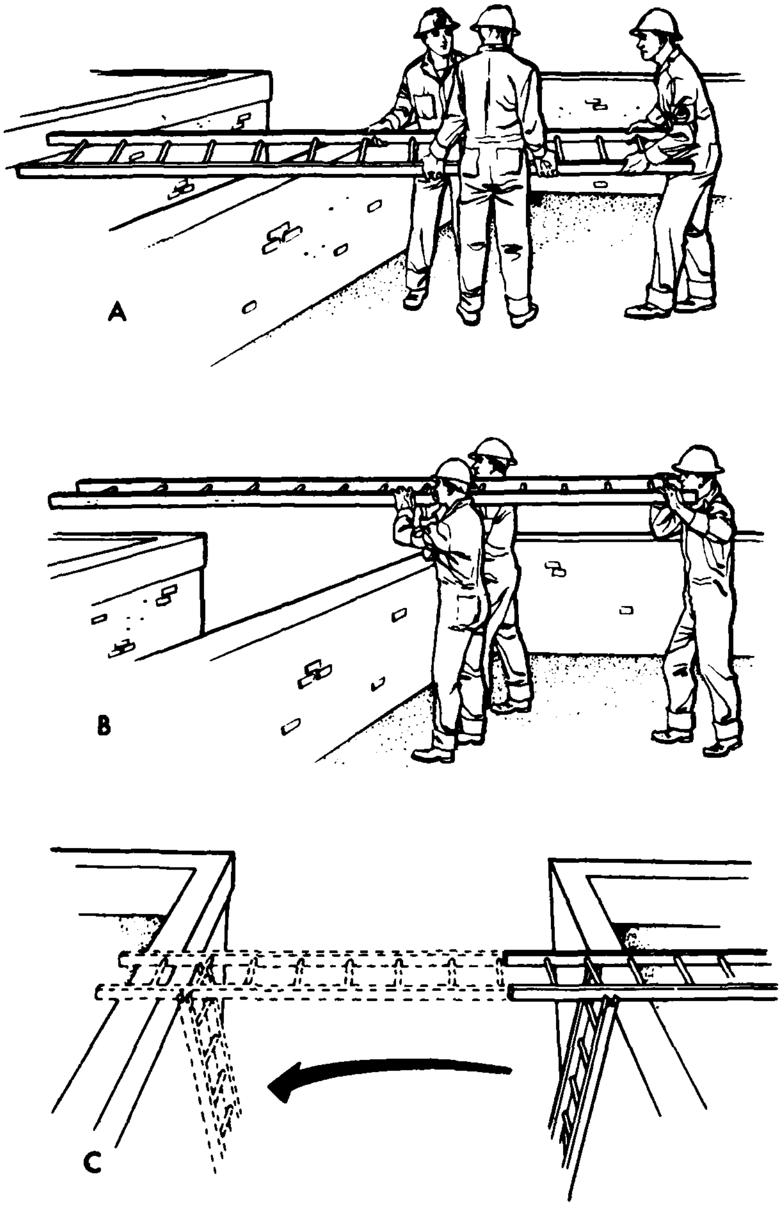
1. One of the best tools for bridging is ladders. They are lightweight, contain tension and compression strength.
2. Scaffolding, used by construction workers, painters, and window cleaners, makes excellent bridging material.
3. General building materials such as beams and timbers may be used. However, their weight is restricted to short spans unless lifting equipment is available. Wood, steel, aluminum, or plastic materials may be appropriate.
4. The fourth material used for bridging is rope or cable. Of course, rope is non-rigid and requires strong anchor points. Distances spanned by this method exceed those where rigid material is used. A good example of this method is the telpher line (discussed intext).

Safety Procedures

Five basic safety rules:

1. The first determination must be that the "bridge" will support the expected load.
2. That two safety lines (one in each direction of travel) be attached to the person or equipment crossing the bridge.
3. That the ends of the bridge are securely anchored or fastened.
4. That only one person be on the bridge at the same time. Remember the fear that people will have about crossing a span with nothing below. A second bridge or safety may be set up under the one used to transport people. This is mainly for psychological effect.
5. When using extension ladders for bridging, the sections of the ladder must be lashed together to prevent separation of the sections.

Bridging is generally considered a last resort for occupant evacuation. It is limited in that buildings must be close together. Generally, higher buildings (5 or more stories) are too far apart for effective bridging. However, it is a method available and should be considered if appropriate.



Bridging gaps with ladders.

RAISING AND SUPPORTING STRUCTURAL ELEMENTS

When floors collapse they tend to hold together. Walls frequently fall over in large sections. By holding together and falling in large sections, floors and walls often create voids which to some extent, protect people under them. Jacks, levers, hydraulic spreaders, block and tackle, etc., will have to be used to lift these heavy sections. In this type of operation, SAFETY, both for the victim and the rescuer, cannot be overemphasized. The rescue team leader must make sure that in raising beams, sections of floors and walls, or other large sections, the stability of the rest of the building is not disturbed, causing further collapse. The resuue team leader must be sure that any raised section is firmly supported by cribbing or struts before allowing anyone to crawl under the raised section.

Shoring is the erection of a series of timbers to stabilize a wall or prevent further collapse of a damaged structure which endangers the rescue operations. Shores are temporary and no attempt should be made to restore the structural elements of the building to their original position. Any attempt to force beams, sections of floors, or walls back into place may cause further collapse. It is important to secure all shores in position without shock to the structure.

CROSSTIE or BOX CRIBBING is used to build a temporary support for any section being raised. As the section being raised goes up, so does the crib. The purpose of the crib is to prevent the section being raised from falling in case of an accident or tool failure. Wedges are used to take up any space between the top of the crib and the section being raised.

Raking Shore

If a wall of a wall-bearing building is bulging or out of plumb, shores may be used to brace the wall or hold it in position during rescue operations within or next to the building. These are called bracing, pushing, or raking shores. The principal parts include wallplate, raker, and sole plate.

The wall plate, if possible, should be continuous throughout its length. When used against a bulging wall, it should be backed with shims or wedges, and timbers to provide continuous bearing throughout its entire length.

Rakers are best formed with square timbers or pipe. If only planking is available, nail and planks together to form a box beam. The number of rakers required depends upon the height of the wall to be supported and the number of floors carried by the wall. Following is a rough guide to the number of rakers and the size of timber required for shores of different heights.

Guide for Use of Rakers

Height of Shore (Feet)	Number of Rakers	Cross-sectional Area of Raker Built Up to Approximate Square Section (Square Inches)
20 to 30	1	25
30 to 40	2	36
40 to 50	3	50
Over 50	4	80

There should be one raker for each floor carried by the wall. The raker should be set so its foot forms a 60 to 70-degree angle with the ground. Each raker should be arranged so its centerline meets at a common point with the centerlines of the wall and floor, thus carrying the floor load directly on the shore.

To construct raker shores, nail a cleat to the wall plate where it meets the head of each raker. The wall plate must be secured to prevent it from sliding upward as the rakers are tightened into place. This can be accomplished by extending cleats through openings in the wall or by nailing the wall plate to a window or door frame. If there are no openings in the wall, a stake may be driven in ground and fastened to the wall plate.

A load bearing wall in need of shoring is dangerous, and any nailing or drilling into the wall must be done with extreme caution.

Footings, the platforms on which the lower ends of the raker rest, have to be placed to distribute the weight of the load. The size of the footing will depend upon the resisting power of the soil. Footings should be placed at right angles to the rakers if possible. The footings, or soleplates, should be placed to take the thrust of the raker at an angle exceeding a right angle, so the raker will become a right angle when the raker is tightened. When tightening a raker, do not drive it into position as this may cause further building collapse. Cut a small notch in the foot of the raker and use a pry bar to tighten the raker and move it into proper position.

Soft ground should be excavated and the bottom of the hole sloped toward the unsafe wall to provide the proper angle for the footing. On a hard surface, the sole plate should be built up to the required angle using wedges and stakes driven to hold the sole plate in position.

After placing the cleat on the wall plate and securing the wall plate in position on the wall, raise the top of the raker to the cleat and place the foot on the sole plate. Gently force the entire structure into place. Nail a cleat to the sole plate at the foot of the raker to secure it.

Nail struts or braces between the bottom of thw alll plate and the raker to prevent the wall plate from sliding up under the strain. In supporting a wall, wall plates and rakers should be placed at intervals of 8 to 12 feet depending on the circumstances, type of wall, degree of damage, and type of footing.

Flying Shore

A flying shore is used to brace a damaged wall when a sound adjacent wall can be used as a means of support. The principal parts are the horizontal beams, wall plates, and struts. Cleats, wedges and straining pieces are used to tighten the flying shore in place.

To construct, nail cleats on the wall plates, one pair to support the horizontal beam or shore, and the others to support the struts. Set the struts at an angle not greater than 45 degrees to the horizontal beam. The struts are kept apart with straining pieces, the length of which are determined by the length of the beam.

Proper measurements and angles can best be achieved by laying out the job on the ground. While holding the wall plates in position, place the horizontal beam in the center cleats, and tighten with wedges inserted between the shore (beam) and wall plates. Next, place the struts and straining pieces into position and tighten with wedges. Cleats may be used to brace the shore more rigidly. The wall plate should be continuous throughout its length, with packing between the wall and wall plate to provide continuous bearing.

Flying shores should be placed along a wall at intervals of 8 to 12 feet depending on the situation, type of wall, and the degree of damage. Flying shores are not recommended for use between two walls separated by more than 25 feet.

Frequently a weakened foundation or damage to the lower portion of the wall makes it unstable. The lower part of the wall and its footing, or foundation, of a wall-bearing building must carry the entire weight of the structure above it. Therefore, bracing or shoring on lower parts of the wall should be stronger than corresponding work on the upper portions.

Dead or Vertical Shore

A dead or vertical shore is used to carry the vertical or dead load of a wall or floor. The parts of the vertical shore are the strut, headpiece and sole plate. Wedges are used to load the strut.

Struts preferably should be made of square timber, heavy enough to carry the maximum load expected. It is difficult to estimate what load a strut must carry and to gauge what load the strut timber can support. Therefore, struts should always be made a little heavier than appears necessary. The size used will be determined by the weight of the wall or floor to be supported, and by its height.

For a given size timber, the shorter the strut, the greater load it can carry. A strut will be much stronger in service if the ends are cleanly cut so they fit squarely to the sole plate and head piece. A strut of square cross section is stronger than a rectangular one of the same cross section area. Straight pieces of pipe are good material for struts.

The sole plate should be made as long and wide as practicable to spread the load over a sizeable area. The sole plate should not be placed on a cellar arch or timber floor if there is doubt that the arch or floor can carry the load. The sole plate must always be supported from below. Where struts are used on the upper floors of a building, the strutting should be repeated on all the floors so the load will have a solid foundation. An exception is when a strut can be supported on a heavy beam in a part of a building which has suffered little damage.

The head piece should have approximately the same cross section as the strut. However, the load being carried will be a determining factor here; also the span between struts where two struts are used. This span should be kept as short as possible because the shorter the span, the greater load the head piece can carry.

With the sole plate in position, set the strut against the head piece. Wedges are set under the strut and the strut is driven into position with the wedges until the strut takes the weight and no more. Wedges should not be driven tighter, since that would lift the wall or floor being supported and might cause more damage.

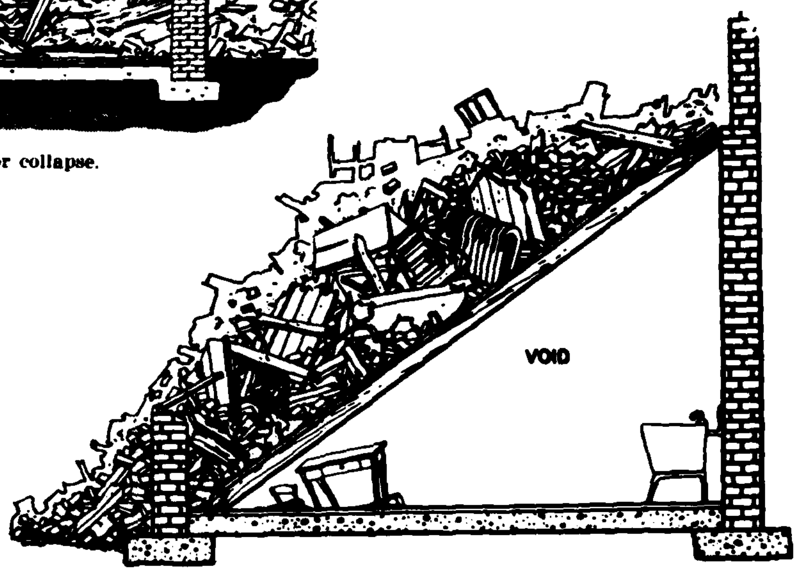
Strutting

Strutting is employed to strengthen window and door frames when they are unsafe due to being cracked or damaged. Two methods of strengthening such openings are shown in the following illustration. Many methods of strutting may be employed, but in all cases, sufficient room must be left between the struts to enable rescue work to be done.

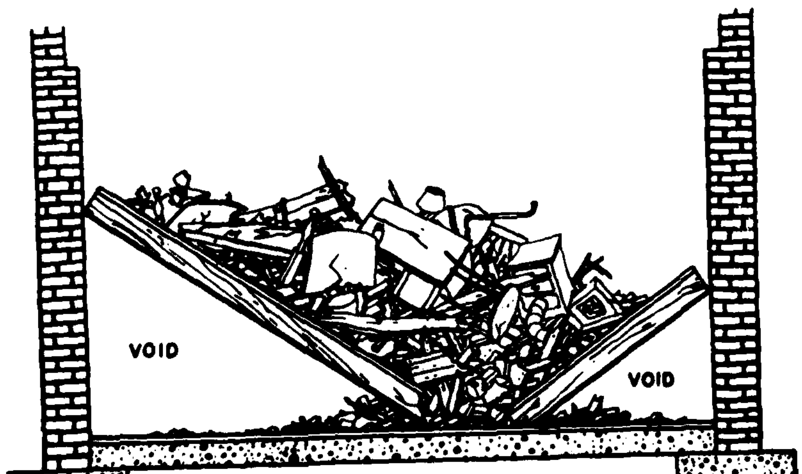
When supporting window or door openings by the use of strutting, the main timbers can be cut to approximate length, then wedges are driven in to load the timbers. Again, no attempt should be made to straighten the opening; use just enough force to support the opening.

Usually at the scene of an explosion or natural disaster, there is ample material available from destroyed or damaged buildings to use for the construction of temporary supports during rescue operations. Through the utilization of the tools available, materials for the construction of temporary supports can be recovered, cut to proper lengths and installed. There is no need to wait until building material can be delivered to the site; use what is available.

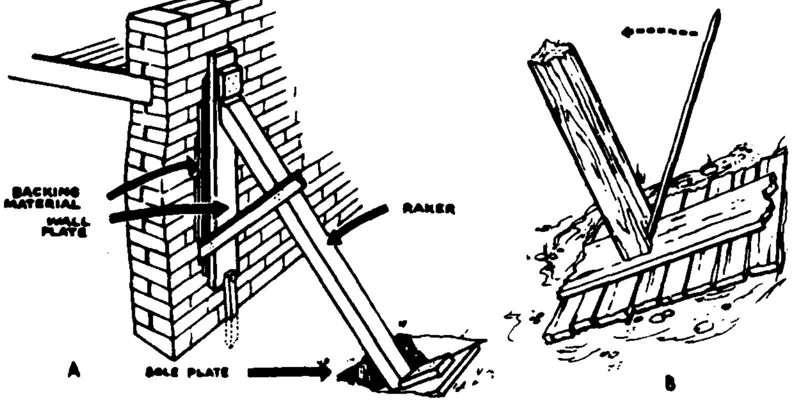
Pancake floor collapse.



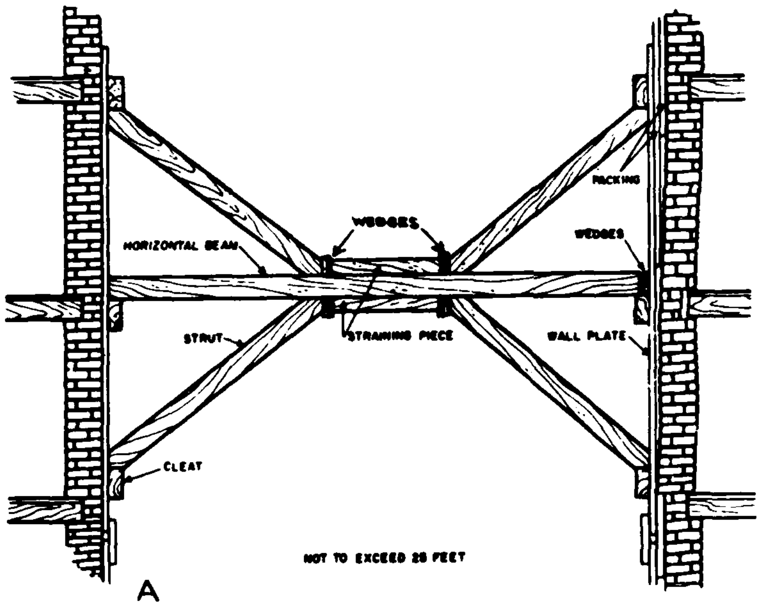
Lean-to floor collapse.



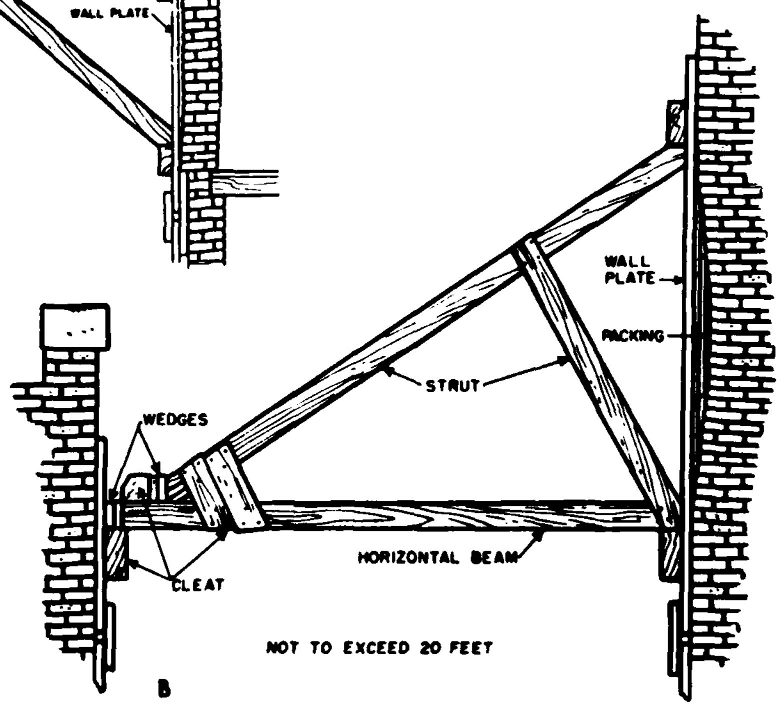
V-shape floor collapse.

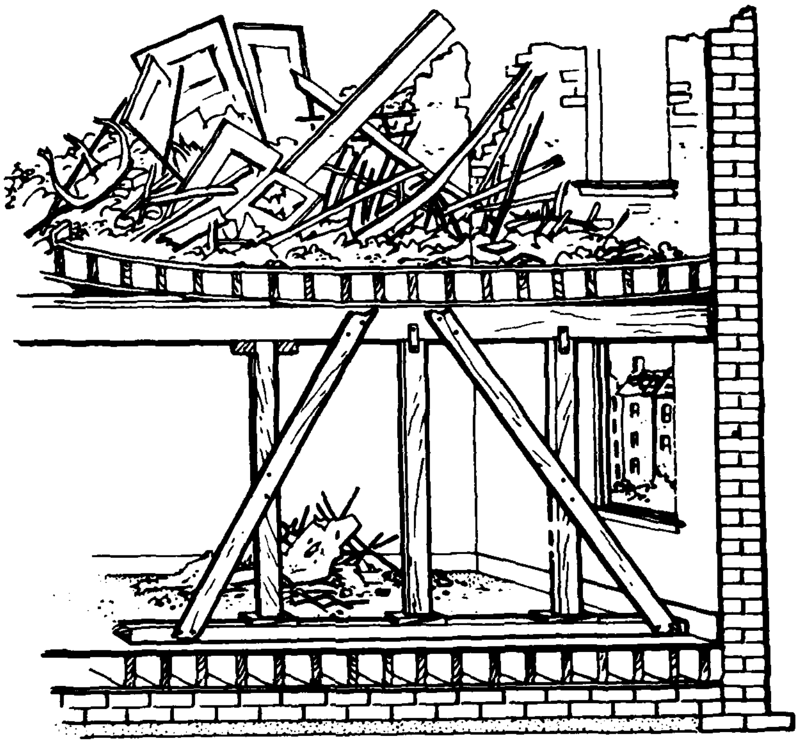


Raking shore.

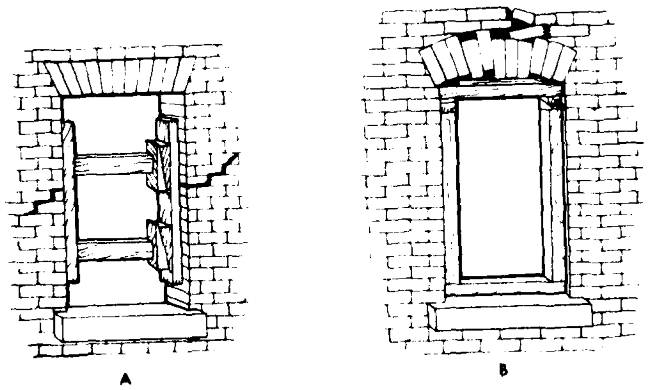


Flying Shores





Dead or vertical shore.



Strutting window openings.

DEBRIS TUNNELING

Tunneling is a means used to reach casualties, usually when their location is known. It is slow, dangerous work, and should be undertaken only after all other methods have been exploited. Tunneling should be carried out from the lowest possible level, should not be used for general search and must not be aimless. Occasionally, tunneling may be used to reach a point, such as a void under a floor where further search is to be conducted.

A tunnel must be of sufficient size to permit rescuers to bring out casualties. It should not be constructed with abrupt turns. Tunnels as small as 30" wide and 36" high have proved satisfactory for rescue work. Whenever possible, tunnels should be driven along a wall, or between a wall and a concrete floor, to simplify framing requirements.

Debris tunneling is quite different from tunneling through undisturbed earth, although strutting and bracing are necessary in both methods. The speed at which a debris tunnel can be constructed varies with the nature of the debris and the size and shape required. Because debris is unstable and key beams have to be left in place, the shape and path of a tunnel through debris is often irregular. Thus, a definite pattern of timbering, as in a tunnel through earth, may not be possible.

The size of timbers used for bracing is governed by the nature of the job and the equipment and material available. It is always better to use timbers which are too heavy than those which are too light because of the uncertain weight which they must support.

In debris tunneling, constant watch must be kept for key timbers, beams and girders, the disturbance of which could cause movement of the pile and collapse the tunnel. (Recognizing these key pieces may be difficult.) To avoid any accidental movement, horizontal pieces should be secured by a prop, or shore placed under them, still allowing passage of both men and stretchers. Time spent in careful bracing will not be wasted when compared with the time necessary to rescue the workers and reconstruct the collapsed tunnel.

When piles of debris are large, it may be advantageous to sink a shaft to reach a desired level or a basement opening, and then tunnel horizontally to reach a victim. It is important to remember that even though the debris material appears to be solid, the sides of any shaft must always be braced and supported, and the timbers wedged securely into place.

Tunnel Construction

The method recommended for constructing a debris tunnel is by the use of frames and forepoling. Frames are the primary supporting elements of the tunnel. They should be prefabricated outside the tunnel and assembled in position as the work progresses. Forepoling is the use of planks or boards driven between the collar and crown-bar of one frame and extending beyond the next frame into the debris. Material for timbering and lining debris tunnels can usually be found in the wreckage.

To begin the tunnel, three frames are constructed. The first frame does not require a collar or spacer blocks at the top, nor do any of the temporary frames. The second and third frames and all other permanent frames in the tunnel require 2" spacer blocks and a collar piece set on top of the crownbar. Frame No. 3 is set first against a cleared vertical face of debris and then frames No. 2 and No. 1 are placed next at approximately 3 foot intervals and solidly braced. Frame No. 1 should be diagonally braced to stakes driven solidly into the ground, about 2 to 3 feet in front of each strut. After the frames are in place, the top is covered from Frame No. 1 to Frame No. 3 with long pieces of lumber such as floor joists, roofing, or flooring. Beyond Frame No. 3, forepoles need to be long enough to overlap only from one frame to the next.

The sides are lined in the same manner as the roof of the tunnel, driving boards between the frame struts and the rubble. To insure stability of the tunnel thus far completed, debris is piled against the sides and over the top. When completed, the frames should be completely covered with the exception of the first frame and diagonal braces.

When debris is removed about 2 feet beyond the third frame, the load on the forepoles may make it necessary to construct a temporary frame firmly wedged under the forepoles until enough debris is removed after the permanent frame is properly braced and lined. This procedure is repeated until the tunnel is completed.

The debris of a demolished structure includes small rubble and dust, which will tend to trickle through the timbering. At first this may not seem important, but the escape of this material in quantity may disturb the mass of debris, causing internal movement. A tunnel should be boarded as closely as possible to minimize debris entering the area.

Rectangular framing has certain disadvantages in debris tunneling. Since frames are not rigid, unbalanced side pressures may cause them to collapse. In some instances, short debris tunnels with small cross sections may be driven in the form of a closed triangle using heavy planks keyed together at the ends.

Regardless of the method used, the strutting and lining in a debris tunnel must be as rigid and tightly wedged as possible. Rigidity and wedging will keep the lining in position and prevent it from being broken by the impact of shifting or moving debris.

There are several different approaches to the problem of gaining access to the basement area of a collapsed building. Where ground floors have not collapsed, a small area may be cleared either by tunneling along a floor, or otherwise removing debris and cutting a hole in the floor to gain entrance. Where the floors have fallen and the basement ceiling completely collapsed, a sloping tunnel may be driven from the edge of the debris downward to the floor of the basement. A shaft may be sunk next to a building and into the ground along the basement wall, through which a hole into the basement may be made.

If a floor has collapsed forming a void against one wall and there appears to be a void against the opposite wall, a tunnel may be driven through the debris from the first void toward the opposite wall to reach the second void. It should be remembered that debris tunneling is one of the most difficult jobs in rescue work and should be undertaken only when other means of gaining access are impractical.

TRENCHING

An open trench can be completed more quickly than a tunnel if the debris is not piled too high. Trenching and tunneling operations may sometimes be combined, with a trench extending into the debris until a tunnel becomes more practical.

To trench through debris, start by removing the larger pieces of timber, stones, or other objects from the face of the pile nearest the objective. Clear a way into the debris by shoveling and other hand methods, removing the minimum amount of material necessary to provide a safe passageway. Progress is governed by the type of debris through which the trench is made.

Trenching may be dangerous. If a trench collapses, the worker has little chance of avoiding injury. To avoid collapse or dangerous movement of the sides of a trench, bracing or some other method of retaining the sides may be required. One satisfactory method of support is to build retaining walls, usually with lumber found at the scene. Horizontal bracing of the retaining walls is necessary.

Material removed from a trench should be piled at some distance away from the edge where it will not fall back into the trench or have to be moved again. The size of the trench will be governed by its purpose and the nature of the debris. Trenching is used to reach a specific point, not for general clearance. The decision may be made to start two or more trenches to a given point simultaneously since it is not always possible to determine the fastest route.

BREACHING WALLS

Many different types of construction will be encountered during rescue operations. These include walls made of brick, stone, concrete block, reinforced concrete, metal and wood. Size-up is very important when the decision has been made to cut through walls or floors to gain entry to a collapsed or damaged building. Try to locate sections of the structure in which the cutting can be done most quickly and safety. Care must be taken to prevent collapse when cutting away wall sections, especially with power tools. Be sure that the support beams and columns are not weakened. Temporary support (shoring) may be necessary before cutting operations can be done safely.

One of the areas that may be considered as a safe place to cut through a wall would be the standing walls of an elevator shaft or stairway in a multi-storied building. However, in the majority of cases, the walls of elevator shafts and stairways are made of reinforced concrete and will be very difficult to breach.

Reinforced concrete walls and floors are difficult to cut through even with power tools. In all walls and floors except concrete, the best method is to cut a small hole and then enlarge it. With concrete, however, it is better to cut around the edge of the section to be removed. The reinforcing bars can then be cut and the material removed in one piece.

When breaching walls or floors using power tools, unless proper precautions are taken, the vibration from the tools may cause further collapse. Metal sheeting can be encountered in roof coverings as well as walls. Metal covered with tar or other material is commonly used in many buildings. When attempting to make entry and the metal has been exposed, it will be necessary to cut through the metal. Whatever is used to cut the metal presents a danger of fire, and proper precautions must be taken before cutting operations begin.

Openings large enough for rescue purposes usually can be made in brick walls without danger of the masonry falling. The bricks should be removed so the opening is arch-shaped.

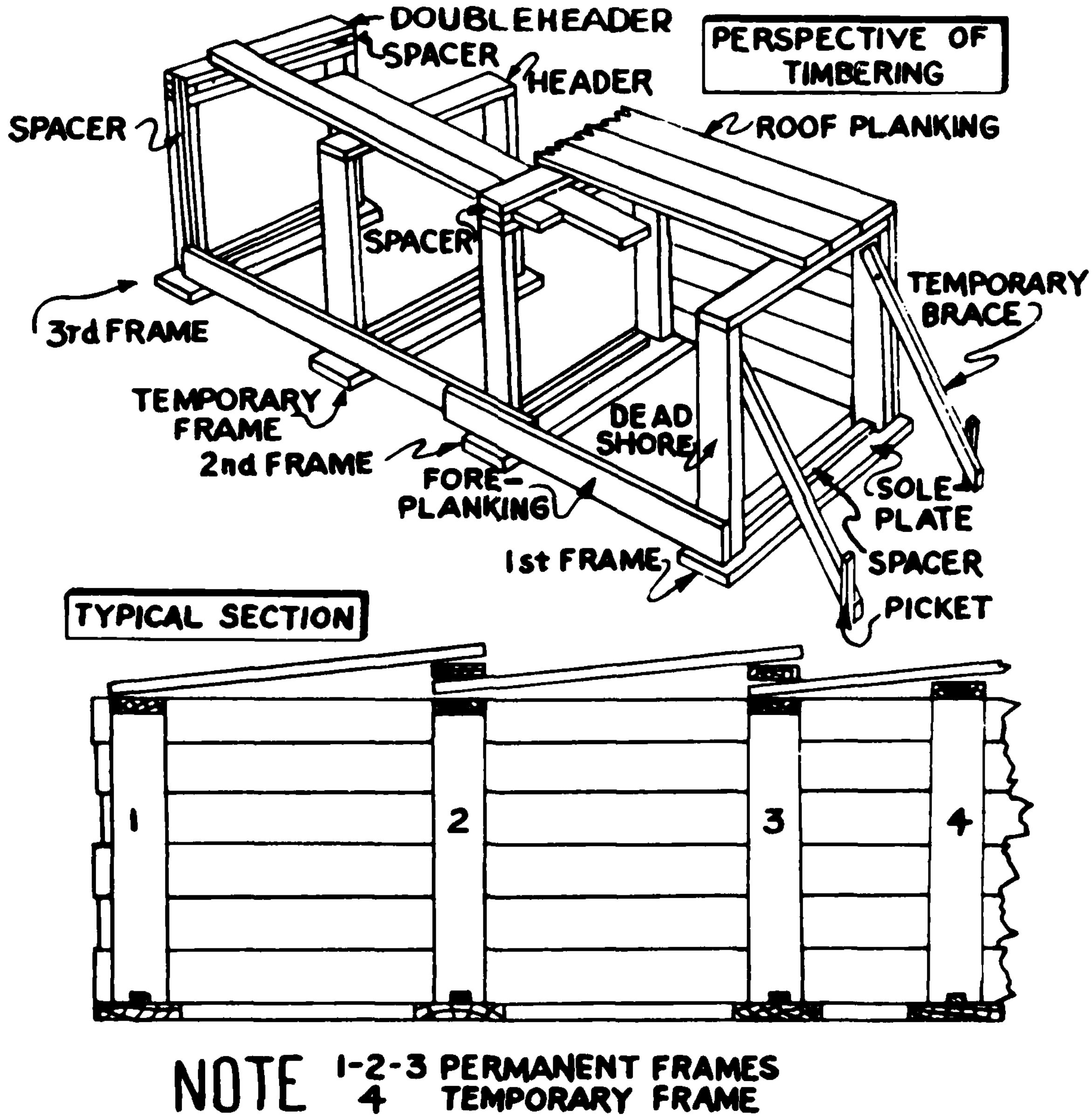
DEBRIS HANDLING

Standard hand tools such as shovels and picks are used in debris removal only when the location of the casualty is definitely known and all other casualties have been accounted for. Recognizing a body in debris is sometimes difficult and tools have to be used with great care to avoid further injury to the victim. Debris close to a victim's known location, or expected location, should be removed by hand only.

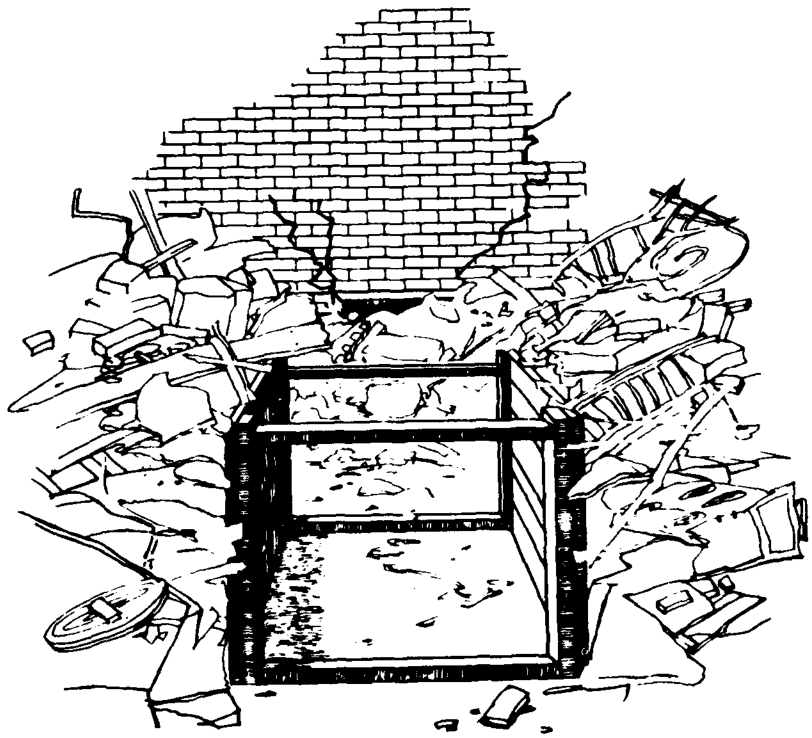
Debris must be removed from the immediate area, and wheelbarrows, baskets or buckets can be used to transport the debris to an area clear of the damaged structure. If the debris has to be piled in the street, be certain it does not block traffic. All debris removed from a structure should be marked to prevent confusion.

Extreme care must be exercised when cranes, bulldozers or other power equipment is used for debris clearance to gain access to victim locations. Care must be taken so the use of heavy equipment does not cause further building collapse and hinder rescue operations. Such heavy equipment should be under the direction of the person in charge of the rescue.

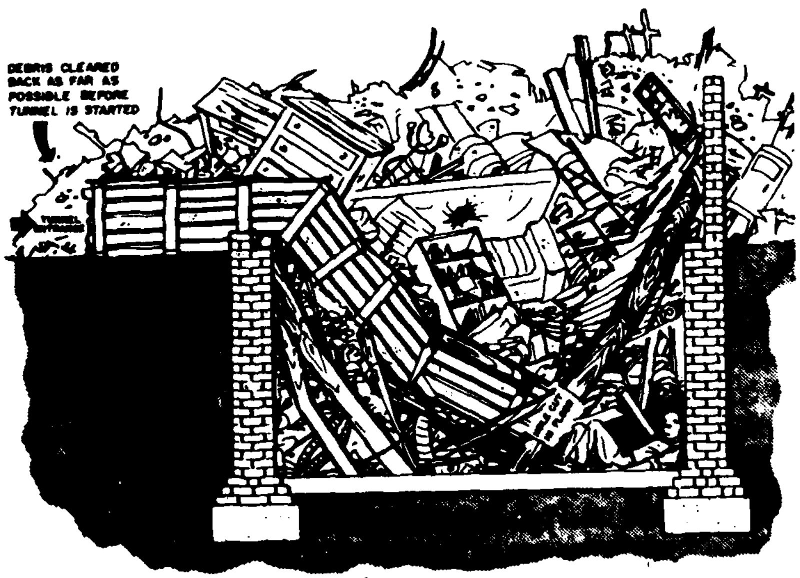
DEBRIS TUNNELING
CONSTRUCTION OF TUNNEL



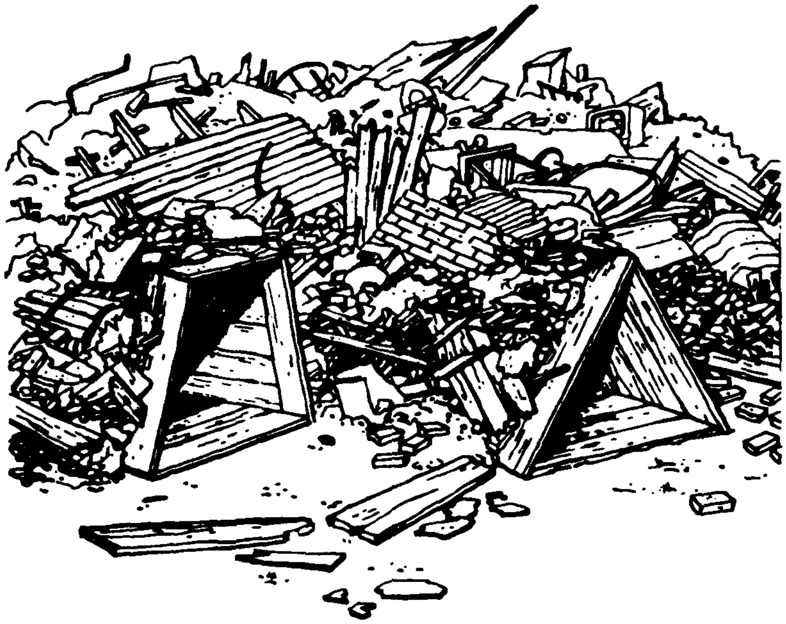
Tunnel construction.



Trenching.



Tunneling to reach void.



Triangular tunnels.

Tunneling to gain entrance.

VENTILATION

When constructing a tunnel or otherwise working to gain access to a damaged building, dust and the possibility of encountering flammable or toxic gases must be considered. Dust can make it impossible to work in a confined area as in tunnel construction, and a supply of fresh air is needed. Most buildings will be supplied with natural gas, and the possibility of encountering gas leaks from damaged utilities must be considered. Also, industry uses many different types of flammable or otherwise harmful materials which could produce a hazardous atmosphere.

Any time rescue personnel are working in a contaminated atmosphere either from smoke or chemicals, self-contained breathing apparatus shall be worn. Even with SCBA, a supply of fresh air will be needed in tunneling operations to free the area of dust and provide the rescue workers with a tolerable atmosphere.

An adequate supply of fresh air can be provided many ways. Air compressors with hoses, fans, and bottles of compressed air are all ways of providing an adequate air supply. Care must be taken to see that the air exhausted from the operation is not recirculated back into the tunnel, and that exhaust fumes from gasoline-driven engines are discharged away from the operation.

If rescue work is being carried out in a hazardous atmosphere, care must be taken in the selection and use of tools. Before any open flame or other possibility of sparking is allowed, check the atmosphere for flammability. Utility companies and fire departments have resources available for the testing of flammable atmospheres.

It may be necessary to supply trapped persons with fresh air until rescue operations can be completed. One method is to use an air compressor for the source of air. A piece of pipe can be pushed into the debris close to the trapped victims. A hose can be run from the compressor to the pipe. When using this method, care must be exercised that the jet of air does not disturb dust and make the atmosphere worse.

It is extremely difficult to work in a debris tunnel with self-contained breathing apparatus. If the atmosphere is not toxic, ventilation can be accomplished by running a hose such as the type used to connect clothes dryers to exterior walls (4" diameter, wire bound, plastic covered), and discharging air from a compressor or bottles into the hose.

UTILITIES

Utilities are those products manufactured, produced, refined, transported, stored, and distributed for consumption by customers of the Utility Company. Utility companies may be public, government, or private enterprises.

Utilities commonly used are:

- Electricity
- Natural Gas
- Liquefied Petroleum Gas (LPG)
- Water
- Fuel Oil

There is a need to "control" utilities during emergency rescues, either to a single facility or designated area that may be widespread. Utilities can present hazards such as ignition sources, toxic atmospheres, electrocution, explosions and fire. Water should not be overlooked as it may cause additional hazards to victims as well as rescuers.

Types of Common Utilities

Electricity

Safety at emergencies involving electrical conductors and equipment cannot be overemphasized. Electrical service may be overhead or underground, and voltages may range from 240 to 750,000 volts.

Consideration should always be given to de-energize all electrical circuits that could possibly be involved with the rescue incident. Remember, unless the circuit is arching, it is not known if electricity is present. Also, by indiscriminate de-energizing of circuits, additional hazards could be created. If you are unsure of the situation, call an emergency utility crew for assistance.

Remember, many occupancies have emergency generators which will automatically turn on and energize specific appliances and lights in the event of a power failure or shutdown.

Natural Gas

Utility natural gas is distributed almost exclusively by a million-mile-plus network of underground pipelines in the United States and Canada. It is transported from gas wells within producing areas in large-diameter transmission pipelines at pressures up to 1,000 psi. These pipelines are tapped for domestic supply and generally operate from 1/4 psi to 60 psi. Regulators and safety relief devices are used to control pressures.

Natural gas is non-toxic, but is an asphyxiant. This is in marked contrast to the manufactured gas wiich was formerly widely distributed as utility gas and contained quantities of toxic carbon monoxide.

Utility natural gas has no odor and is generally odorized as distributed, and is lighter than air. Natural gas is highly flammable and will explode. In the event of any major disaster, natural gas mains and feeder lines will be broken or involved.

Steel and cast iron pipes are used extensively. In recent years, thermoplastic and thermosetting plastic piping has been used extensively in distribution and service piping at pressures up to 60 psi. The color of this plastic pipe is a salmon/beige. It is distinctly different from plastic colors used for other types of service.

Natural gas is detected by its odor, and the most common cause of ignition is static electricity. However, any ignition source will ignite it with explosive force.

Both metal and plastic lines may be capped by redwood plugs, or by crimping or bending the line back over itself (these methods are successful for lines up to three inches in diameter). All lines must be grounded before capping operations. Lines larger than three inches must be shut down by section or control valves.

The local utility company is your best resource for assistance in controlling natural gas incidents. They have line maps, special tools, and knowledge to effectively assist in this effort.

Water

Of all the utilities, water is the safest from a fire or explosion standpoint. However, it has tremendous force, weight, and an eroding effect that can undermine any structure or crush or sweep away most man-made and natural barriers. The best way to control water utilities is by the local water company. Water can compound any existing adverse condition tenfold and must be recognized.

POWERED DIGGING RESOURCES

"Prime mover" is a broad term used to describe powered digging equipment applicable to heavy rescue uses. To utilize the proper equipment for a given job requires that the capabilities of such equipment be known and available. Valuable time can be wasted trying to obtain an unsuitable tool for a situation.

The following outline is intended to offer an approximation of equipment types and how each may best be used:

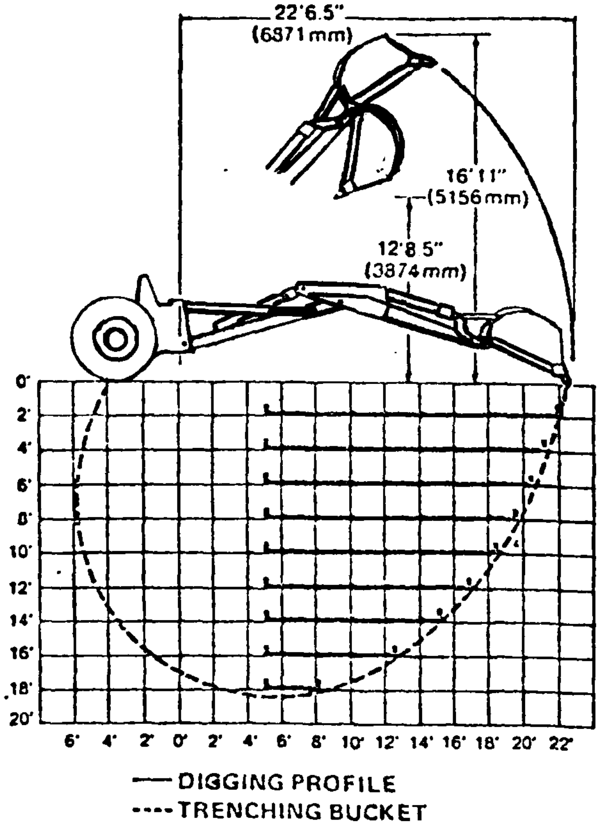
The backhoe is a hydraulic, two section arm with a hydraulically-controlled bucket holding about two cubic yards. The length of the arm is the controlling factor in the depth to which the backhoe can dig. As a rule, it is safe to consider that a backhoe can dig a trench or hole about two feet less in depth than the maximum length of its arm. Commonly available arms are 14, 16, 18, and 22 feet. Bucket widths will vary from 12 to 30 inches. The hydraulic arms which power the bucket are also useful as a light duty crane and can be used to lift 800 pounds safely through a full range of motion. Equipped with hydraulic stabilizers and in some cases self-levelers, the backhoe can cut vertically on side slopes up to 12 degrees off level. It is important to try to make cuts no greater than vertical, as it is very easy to create an unstable position for the machine due to undermining its foundation. Backhoes can be mounted on a wide range of wheeled and tracked vehicles. Caution must be exercised in utilizing a backhoe in excavations in loose or wet soil, as normal operating vibrations can result in cave-in or tip-over for the equipment. For this reason, great care should be taken to provide for large area bases for stabilizers or jacks.

Trenchers are large, usually tracked vehicles, having a single hydraulic arm upon which a bucket wheel is attached. While trenchers dig much faster than backhoes (5 times), they do not dig deeper and are not as versatile. They are an outstanding choice for building dike and diversion channels.

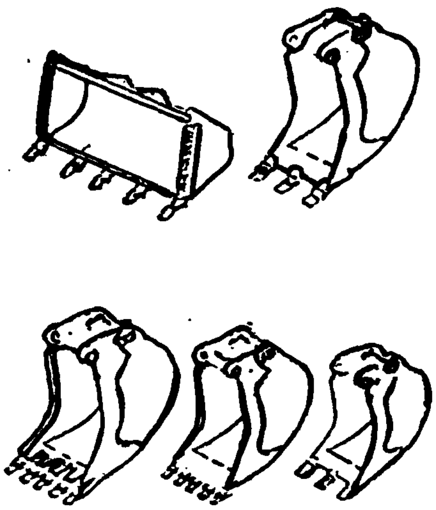
Loaders are a term to describe vehicles with a power-operated bucket; they may be wheeled or tracked. The size of the bucket will vary widely according to the machine it is mounted on. Buckets have only a limited capability to excavate below the level -- normally about three feet for rescue work. The bucket-style, referred to as a "4-in-1" is an excellent choice due to its wide versatility.

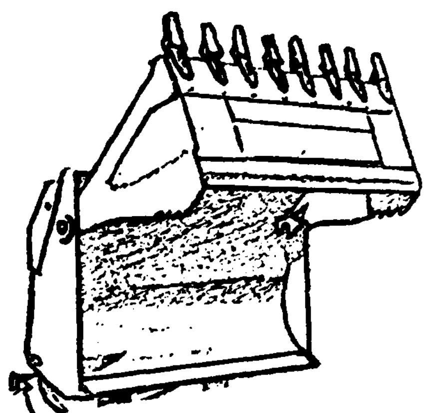
Power Shovels are related to backhoes, and sometimes referred to as excavators. The power shovel differs from the backhoe in that it can provide greater depth of excavation (up to 40 feet), although this is not true in all cases. Power Shovels may be wheeled or track-mounted.

As a general rule, prime movers should be used to make excavations for men to continue, not in conjunction with, rescue operations. Because of the accident potential, no one (victim included) should be in the immediate area of the equipment selected. All excavations should be adequately shored before operations commence.

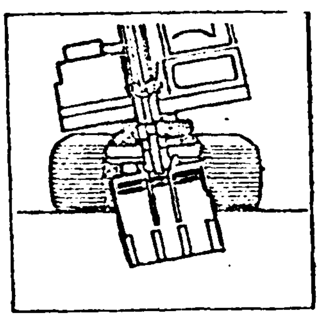


TRENCHING ATTACHMENTS

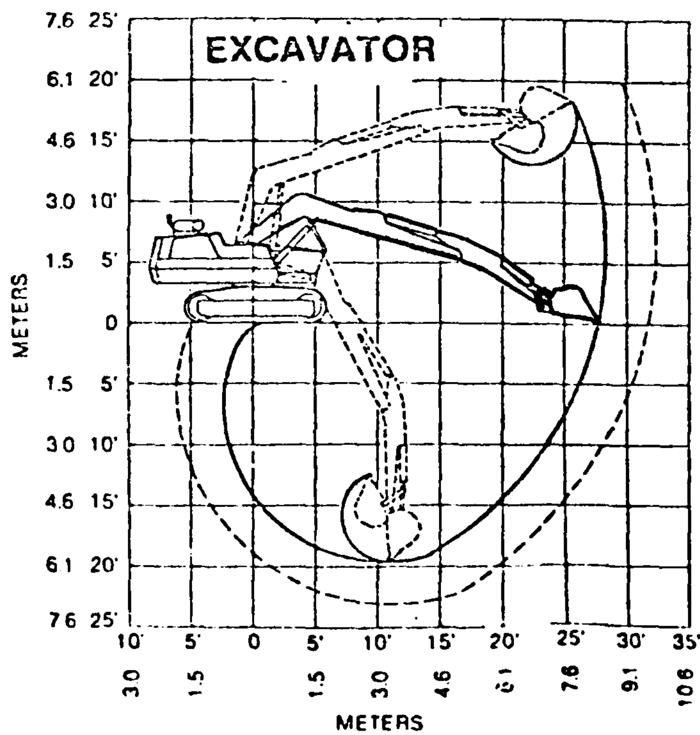




4-IN-1-BUCKET



Angle trenching reduce, Cave-In-
potential



ELEVATORS

The elevator is the life-blood to modern office and residential buildings. Without it, the large, high-rise buildings we know today would be nonexistent for obvious reasons.

Elevators have an exceptionally good safety record, and are in fact, the safest form of public transportation. The miles traveled annually by elevators exceed those of any other form of transportation.

Hydraulic Elevators

Hydraulic elevators are found in two different types. In the plunger-type, the car rides on top of a tall hydraulic piston. The piston cylinder extends deep into the ground, and water or oil pressure is used to raise and lower the piston and car. The car may also be partially supported by steel wire ropes passing over a sheave at the top of the shaft, then down to a set of counter-weights.

In another type hydraulic elevator, the car is supported by hoisting cables similar to ordinary electric elevator cars, but the motive power is a hydraulic machine which is connected by an arrangement of sheaves to the hoisting cables.

Hydraulic elevators are used in limited-height buildings -- less than six stories in height.

Electric Elevators

The drum-type elevator is usually an old installation and has a large drum in the motor room upon which the hoisting ropes and counterweight ropes are wound. This type elevator is not used in tall buildings because the drum size would be impractical. Other operating difficulties have made them largely obsolete.

The modern elevator is of the traction type which employs a driving sheave, or a pulley with multiple grooves, over which pass six or more hoisting cables that lead from the car to the counterweights. The traction principle provides many safety features, permits multiple hoisting cables and allows installation in buildings of any height.

Elevators are used to transport passengers, freight, and equipment, and are found in occupied buildings and those under construction. This manual will address only elevators used for above-ground conveyance. Rescues from below ground (such as mine shafts) present unusual problems requiring special equipment and training.

Action Priorities

Elevator equipment is designed to protect passengers by preventing movement of the elevator if proper conditions for operating are unsatisfactory, and by stopping the elevator if any unsafe conditions occur while the elevator is operating. Most disabled elevators stop

within two feet of a landing. However, this may not be the case in blind shafts.

The vast majority of elevator incidents results in passenger inconvenience only and will remain that way if handled properly. Most elevator incidents (99%) are caused by electrical failure or some minor mechanical defect.

There are four priorities the rescuer must consider:

1. Determine that the elevator(s) are not operating and passengers are, in fact, inside the elevator car.
2. The exact location of the elevator car with the "trapped" passengers.
3. If the passengers need to be removed.
4. The safest way to remove the passengers.

Plans for removing passengers from disabled elevators, regardless of the cause, must be based on a high degree of safety, knowledge, preplanning, and common sense. Do not remove passengers from a safe situation into one of risk or hazard unless necessary.

In all cases, the elevator service agency should be called to dispatch a service mechanic. This, in many cases, saves time and unnecessary equipment damage; and if the situation is not extremely urgent, eliminates the necessity of forcing doors. An elevator mechanic can usually release passengers with his knowledge of lock-releasing arms and their location on the doors.

Access Into Elevators

All elevators have at least three openings into the elevator car:

1. Normal entrance/exit doors (some have front & rear doors).
2. Top emergency hatch.
3. Side emergency hatch.

All are openable from either inside or outside the car.

Emergency Removal of Passengers

If abnormal conditions (1%) are found on examination of the stalled car:

1. Keep talking to the passengers. Reassure them of their safety.
2. Do not promote panic by letting the passengers hear and talk of danger
3. If the hoist cables are broken loose or tangled, keep off the car.
4. If the governor is not set, <u>hand set</u> it.
5. Be sure to <u>open the main line switch and secure it open or pull the fuses</u>. Station a rescue person at the switch.
6. Secure the car to prevent upward and downward movement.
7. Secure car to guide rail brackets.

Remember the importance of not raising the car when securing. Some types of safety devices become dislodged when there is upward movement of the car. Apply props or lashings with sufficient slack so the full weight of the car remains on the safety device.

Prepare to remove passengers through emergency exits only as a last resort.

If passengers are to be removed through a side exit, two rescuers should assist them from the stalled car and two rescuers should receive them in the car alongside. Passengers should be watched closely for erratic behavior and should be held securely during transfer.

If passengers are to be removed through a top emergency exit, a ladder should be used. Pulling passengers up by their arms should be avoided as it can be painful and lead to injury. One rescuer should assist the passenger over the crosshead, using car to prevent stumbling or injury on the door operator or the other car's top equipment. The passenger should be assisted up a ladder to a third rescuer, standing on the floor in the hatchway entrance. A safety belt, with attached rope, should be put on the passenger while he is still in the car, and the rope should be passed ahead and secured at all times against the shock of the passenger falling or showing signs of hysteria.

If the car is stopped above the floor but there is still room for the passengers to lie face down and slide out backwards until their feet are on a ladder, it is imperative that the open hatchway be carefully guarded. Every precaution must be taken to prevent slipping.

If the elevator car is stalled below the floor, there may be sufficient room for the passengers to climb a ladder and crawl out of the car. In almost every case, the elevator can be brought level with the floor in some way so that passengers can walk out. This, of course, is the best way in most cases and can usually be done in less time than any other method.

No set of rules will work in all emergencies. However, passengers on a stalled elevator are safe. Every move, every operation should be carefully considered to keep them that way. Any rescue operation must move along with a minimum of lost time. There is no sense in everyone getting into the rescue operation. Spectators, building tenants, and others may just get in the way or fall through an open hatchway door. Too many persons doing too many things may turn an annoying situation into one of extreme danger.

If there is a large number of stalled elevators due to a general power failure, passengers should be reassured and told they will be taken out and that help is on the way. It is better to leave them uncomfortable and safe than to get them out and risk having an accident. If many elevators are stalled, there will not be enough skilled, experienced people to get all passengers out without a considerable waiting period for some of them.

Under most conditions, removing passengers from a stalled elevator is serious, exacting work. It takes time to get proper equipment on the job and alot of experience to examine the elevator to make sure it is safe. No attempt should be made to tamper with an elevator in an effort to move the car without power. The balance weights of an elevator car are heavier than the car and may permit the car to run out of control, resulting in a serious accident to passengers and major damage to the equipment.

There are two types of elevator doors -- center opening and side opening. If forcible entry is necessary, pry bars, porta-powers, etc., can be used to force the doors sideways in the normal operational direction. Elevator doors should not be forced in as they may come off the overhead track and fall into the shaft, potentially causing damage to the car or injury to passengers. Remember, elevator car doors are attached to the structure (elevator shaft) at each landing. If doors are forced open, this will expose the shaft.

Agencies charged with elevator rescues should contact local elevator companies and preplan such rescues.

P A R T F O U R

CONSIDERATIONS FOR SUB-SURFACE RESCUE

Rescue from sub-surface locations is one of the most complex of all types of rescue. Locations requiring sub-surface rescue can include collapsed structures, tunnels, mines, quarries, sewers, and natural caves. Relatively simple rescue tasks above ground become both complex and demanding as the rescue team goes underground.

There are six main areas of concern which must be considered in any sub-surface rescue:

1. Personnel safety and equipment
2. Communications
3. Victim Transportation
4. Auxiliary resource identification
5. Atmosphere
6. Route selection

All personnel must be properly equipped, experienced, and psychologically and physically fit to work underground. If not, time must be taken to integrate those persons into the team who have these special skills. The admission that you or your team or agency can't carry out the rescue unassisted is ego shattering, but necessary if the victim is to be evacuated. Preplanning should be used to contact those who you might need for sub-surface rescue in advance of an emergency.

The need for communications systems and plans for use in sub-surface rescue cannot be overstressed. Next to proper manpower, a communications capability is mandatory as the very nature of sub-surface rescue hinders all forms of traditional communications.

Victim safety and transportation <u>will</u> require the use of specialized litters and medical supplies. Conventional litters will not pass through many obstructions nor will they provide the necessary protection to a victim. Medically, all persons (rescuers included) will be affected by hypothermia due to contact with sub-surface environment, natural or manmade. (There are numerous cases where slightly injured persons have died due to hypothermia protection being lacking or inadequate.) Conventional hypothermia treatments cannot be administered on scene and specialized equipment such as warm gas inhalers and exposure bags must be employed.

A sub-surface rescue is much like rescue opeaations in a high-rise building; i.e., demanding many and varied resources, tools, and techniques. Following is a list of basic specialty resources normally needed in sub-surface rescue:

1. Litters (Niell Robertson Cro; drag litter)
2. Warm gas inhalers
3. Neoprene exposure bags
4. Field telephones - battery powered

5. Hauling equipment
6. Ventilation/atmosphere control/monitors/breathing apparatus
7. Digging, shoring, blasting supplies

Atmospheres underground can vary greatly. Manmade locations are as a rule, in need of ventilation, while natural locations such as caves actively ventilate themselves. When toxic gas is present, it requires elaborate and full-scale ventilation equipment to provide 3,000 CFM airflows. Breathing apparatus of the compressed air variety is inadequate both in terms of durability and duration. As a rule, no man should go into a sub-surface toxic gas location with a breathing apparatus of less than <u>two hours</u> duration.

Gas sampling equipment must be rugged, easy to read, and functional for a very wide range of gases. Units built by Drager, MSA, Bendix, and Bio-Marine are currently available.

Maps, charts, and blueprints are of extreme importance to any sub-surface rescue. Complex questions include where are the victims; what is the best, shortest, most direct route; what features are present to hinder or aid operations. All can be greatly assisted if even only rough drawings are available. Mines and tunnels usually have plans which state departments have on file. Caves also have maps available through local enthusiast groups and national rescue organizations.

In short, preplanning the possible risks and developing and locating proper resources for them are the keys to most sub-surface rescue situations.

PHYSICAL PROBLEMS FOR PERSONNEL

Personnel selected or utilized for sub-surface rescue will be subjected to unusually heavy demands requiring both physical and mental conditioning and discipline. Moving in underground rescue requires rescuers to move through irregular passages which may restrict to difficult squeezeways of 7 or 8 inches in width to vertical drops as much as 400 to 500 feet. To navigate these passeges requires the physical size of rescuers to be considered as well as their ability to deal with such common fears as fear of heights, the dark, tight places, etc.

Agility and stamina are most often the best traits for rescuers rather than brute strenght, as operations can last for days rather than hours.

Experience has shown that underground rescue is much like fire fighting operations in high-rise buildings in terms of manpower needs. This means there must be considerable depth of qualified manpower available as well as a sophisticated command system to coordinate it. Entrance control must be established early in the operation, since only a specific amount of manpower can be physically accommodated within underground confines.

Teams assembled to work for extended periods should be comprised of not less than 200% of the need indicated so that 100% manpower relief may be effected on site without lengthy or difficult travel needs to and from the site (which acts only to tax the strength and endurance of the relief crew). Rotation in demanding situations must be frequent to avoid long-term exhuastion.

Each person must have adequate equipment for himself without borrowing or sharing. Such equipment should include:

- Hard hat with chin strap
- Helmout-mounted light, with backup parts, good for 8 hours minimum use
- Protective clothing - for hypothermia prevention
- Specialty equipment for negotiating difficult or vertical areas
- Light rations - if to be underground for 8 hours or more
- Sturdy rubber-soled, lace-up boots
- Police-type whistle (for inter-group communications)

When manpower is limited or lacking in ability or equipment, outside resources should be contacted without delay. In most cases, such special resources are available rapidly (within 4 hours) and at no cost.

SPECIAL RESOURCES FOR SUB-SURFACE RESCUE

Rescue teams must know how to contact specialty rescue resources for sub-surface rescue operations. In addition, they should recognize what limitations they have and determine at what point outside resources be mobilized.

There are two primary resources for sub-surface rescue available to the United States -- The Department of Labor Mine Emergency Operations; and the National Cave Rescue Commission.

The Mine Emergency teams are available by calling (412) 261-6053. They have vast resources and can accomplish:

- Location of persons trapped by collapse
- Tunneling
- Communications equipment
- Special breathing apparatus
- Engineering assistance

Their scope of operation includes building collapse, mines, quarry and tunnels (all kinds).

The National Cave Rescue Commission can be contacted by calling 800-851-3051. They have resources which can accomplish:

- Location of persons underground
- Evacuation of persons from flooded sub-surface locations

- Specialized medical evacuation
- Specialized vertical and horizontal extraction from difficult sub-surface locations

The scope of their operations includes all natural caves and flooded sub-surface locations.

Both the MEO and NCRC can mobilize their specific resources to most U.S. locations within four hours.

Other resources applicable to sub-surface rescue include:

- Air compressors and hoses
- Field telephones
- Inductive loop radios (through rock or debris)
- Shoring supplies
- Long duration (2 hour-plus) breathing apparatus
- Hydraulic rescue tools
- Manual hauling tools
- Special litters
- Personnel lighting equipment - helmet-mounted
- Air moving equipment
- Diving equipment
- Drilling equipment (well, cassion, etc.)
- Gas testers/analyzers
- Maps and charts of local active and abandoned underground sites -- mines, caves, tunnels, sewers, channels.

COMMUNICATION PROBLEMS IN SUB-SUPFACE RESCUE

When the rescue effort goes sub-surface, special considerations must be given to communications. The needs for communications are actually increased in sub-surface rescue since all visual and physical contact is lost and each unit of a rescue operation or work group is isolated from people even 50 feet away, but just around a bend. Psychological pressures also build, and if communications is lacking, rescuers and victims will be pushed toward panic.

Communications does not have to be entirely verbal. Signals or sounds of any established meaning have importance. Some established non-verbal signals include: O.A.T.H. system, whistle, signals, hammer beats, and even explosive shocks.

The first order should be to establish an overall communication plan for the operation. It should be accomplished according to the following sequence:

1. Communications to report on size up and conditions.
2. Communications to locate victims - coordination/search.
3. Communications to victim - victim morale/rescue rapport.
4. Communications to problem areas - problems which have been identified as requiring solving prior to victim evacuation.

Following is a listing of some of the more common forms of communication devices:

1. Whistles - used to communicate in search and during lifting operations.

One Blast	STOP
Two Blasts	UP
Three Blasts	DOWN

2. Radios - Used for line of sight only. Will not transmit in most sub-surface locations. Newer, inductive loop radios can transmit through great distances of earth and rock. These radios should be located well in advance as they greatly simplify underground communications.

3. Telephones - by far the best and most positive form of communication. Field telephones used by the military such as EE8D, are simple and rugged. Telephones selected for emergency use should be battery operated, magnet actuated style. Sound powered planes have been found to perform poorly under wet and dirty conditions.

   While any two conductor wires will work with field type phones, wire designated "combat wire" by the military is by far the strongest and most durable, being available in 1,320 inches (1/4 mile, 415 M), 1 mile (1.6 KM) and 5 mile (8 KM) lengths.

   Communications can be established at any point in a line by simply scraping away a small bit of insulation and clipping on a portable hand set, which should be issued to all work parties.

   To provide identification and coordination for use of numerous phones on a single wire, each user can be issued a ring or bell code.

ATMOSPHERIC PROBLEMS IN SUB-SURFACE RESCUE

The nature of sub-surface atmosphere will vary greatly according to the situation and location. The number of probable or common gases is actually restricted to carbon monoxide, methane, oxides of nitrogen, carbon dioxide. Others may exist, but not as common hazards and may be unique to the location.

Carbon Monoxide - is lighter than air and produced through the process of combustion. It will be found in all locations where fire or flame producing equipment has been. A concentration of 500 PPM is fatal in 3 hours. Carbon monoxide is attracted to the blood 250-300 times more readily than oxygen, which it then excludes from the body. Carbon monoxide's effects are culminative and repeated frequent exposure to safe concentrations can be lethal. Heavy work will also drastically affect the effects of CO. When carbon monoxide

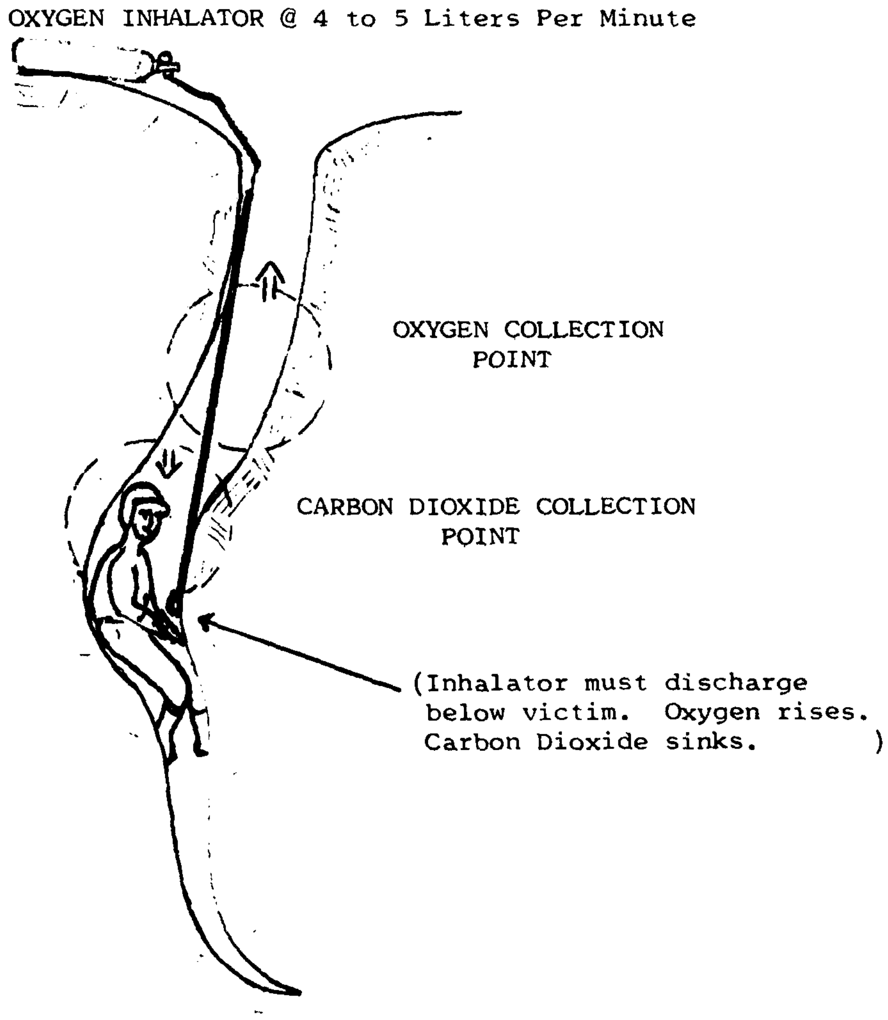
is present in concentrations of 12½ - 74%, it is within its explosive limits. Dispersal of CO through mechanical ventilation is best. Introduction of oxygen will oxidize the CO to CO_2, a heavier-than-air, non-toxic gas. Breathing apparatus is a mandatory item for working in CO atmospheres. Great caution is advised in positioning motors and combustion sources near ventilation intakes or near entrances providing ventilation.

Methane (Natural Gas) - is lighter than air and found in sub-surface locations due to rupture of mains and oxidiation of vegetation. Although it is non-toxic, it can dilute oxygen to the point where the atmosphere becomes an asphyxiant. Over 10,000 deaths in mines and tunnels have resulted from methane's presence. Methane's greatest risk is from explosion at 5-15% concentrations which produce a wide variety of toxic gases as well as fire and concussion. Ventilation is best accomplished with mechanical ventilators with explosion-proof motors of electrical design.

Oxides of Nitrogen - are both heavier and lighter than air. They are found around combustion of high nitrogen content materials. They are also produced by the use of explosives which are "nitrated." Five parts per million should be considered maximum concentration, as it combines with body fluids to create nitric acid in the body as much as 24 hours after exposure. Breathing apparatus and ventilation should be considered at once. Persons exposed must remain under medical supervision for at least 24 hours. Decontamination of exposed metallic equipment should be considered in humid atmospheres.

Carbon Dioxide - is heavier than air gas which is complex in it's effects and not fully appreciated. It will be present in low-lying areas forming "pools" in restricted passages of rooms. It is produced by normal respiration, fire, explosion, and decaying plant matter. While non-toxic, it is an asphyxiant and acts to stimulate breathing which produces even more CO_2. Concentrations of 4% cause breathing effort to be increased 200%; and 4% is produced on one man's exhaled breath, further contributing to the problem. When dealing with victims in wells, cisterns or shafts, it must be understood that heavy CO_2 may fill the shaft with like water and prevent oxygen and normal air from reaching a victim. In such cases, oxygen and/or air must be introduced below the victim, not above him, or it will rise uselessly out of his reach. 5,000 PPM, or 5%, is the maximum safe exposure to CO_2.

In addition to understanding common gases, rescue personnel must be able to determine how long persons can survive in sealed-off areas if there is no air flow in or out. Oxygen will decrease and CO_2 will increase, accelerating breathing oxygen as we have mentioned, and further producing CO_2, which continues on ad infinitum, constantly accelerating. Basically a man at rest will use 7 cubic feet of oxygen per hour, equivalent to about 20 feet of normal air.


OXYGEN INHALATOR @ 4 to 5 Liters Per Minute
OXYGEN COLLECTION POINT
CARBON DIOXIDE COLLECTION POINT
(Inhalator must discharge below victim. Oxygen rises. Carbon Dioxide sinks.)

WATER PROBLEMS

Water problems can be diminished by pumping. Normally the best type pump to use is a positive displacement "trash pump" since it is relatively jam-proof and requires no priming. Centrifugal pumps can be used to pump relatively clear water when access is easy and abnormally large quantities of water must be moved. Pumps have one great fault -- seldom can they draft or lift water over 30 feet. When water must be removed from deep or distant locations, a siphon eductor may be used to push water out. Sipon eductors can lift water in this fashion over 100 feet. For greater distances, siphon eductors can be used in series. Another alternative is to use special deep well pumps; however, these are not generally available.

When water can't be diverted and is present in vast quantities and trapping victims, diving rescue may be the only solution. This situation exists frequently in mines and caves due to flooding. Special sump rescue divers should be called in, as most times local diving skills/abilities are not sufficient. This is the most dangerous kind of diving possible. Properly done, however, it can be the only hope for victims. Sump divers are available nationwide by calling 800-851-3051.

RAISING FROM SUB-SURFACE

When raising victims from sub-surface,locations, it is best to lift *in a horizontal mode.* This is, however, not totally practical, since many times restricted openings or spaces must be traversed which require vertical raising. Effective raising is accomplished in two steps:

1. Provide a dual haul system with appropriate rigging to allow the litter to be transferred from horizontal to vertical and back again.

2. Provide a litter tender to accompany the victim, render aid enroute, and free the load if necessary.

   OR

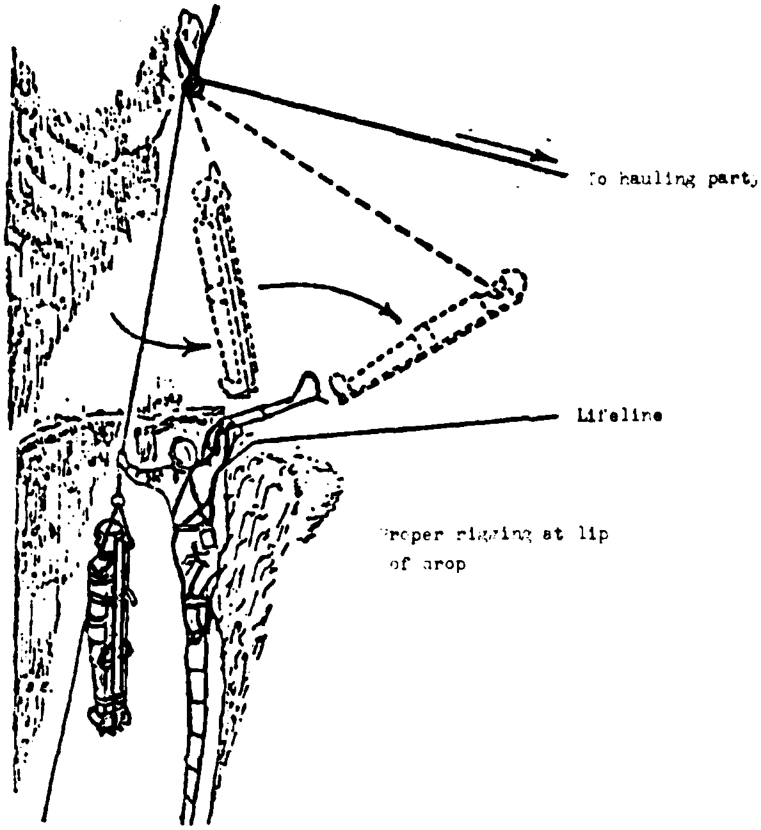
   If a litter tender is not practical or available, a lower guideline attached at the litter's mid-point should be considered.

The rigging for sub-surface lifts should be positioned to allow the haul line to hang free of any walls or obstructions. A directional pulley should also be positioned well above the edge of the drop so the load does not have to be lifted or dragged over the edge or lip. When this is not possible, short lengths of line may be pre-attached to the litter or load on each side, at mid-point so leverage can be generated to raise the litter above the edge or lip.

Power winches should not be used in raising humans from sub-surface locations, as the operator can't adequately supervise the operation from his position. Manual power should be all that is required since loads seldom are over 500 pounds.

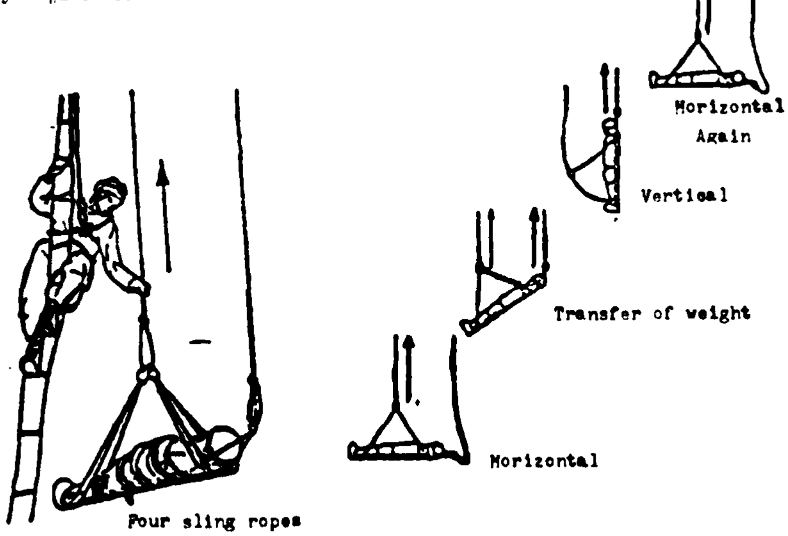
Where manpower is lacking, power for the lift can be accomplished by:

- The Z-lift with prusik safety
- Counter-balance method
- Come-a-long or pulley system with prusik safety



Proper rigging at lip of drop

A properly rigged litter must be readily adjustabe.



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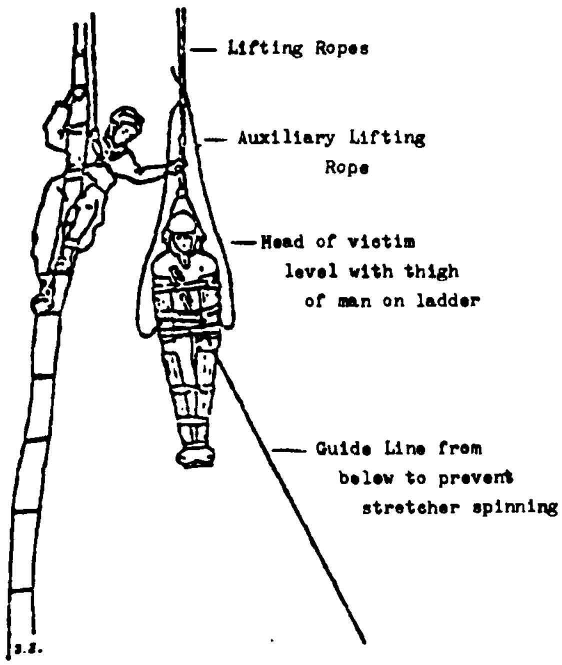
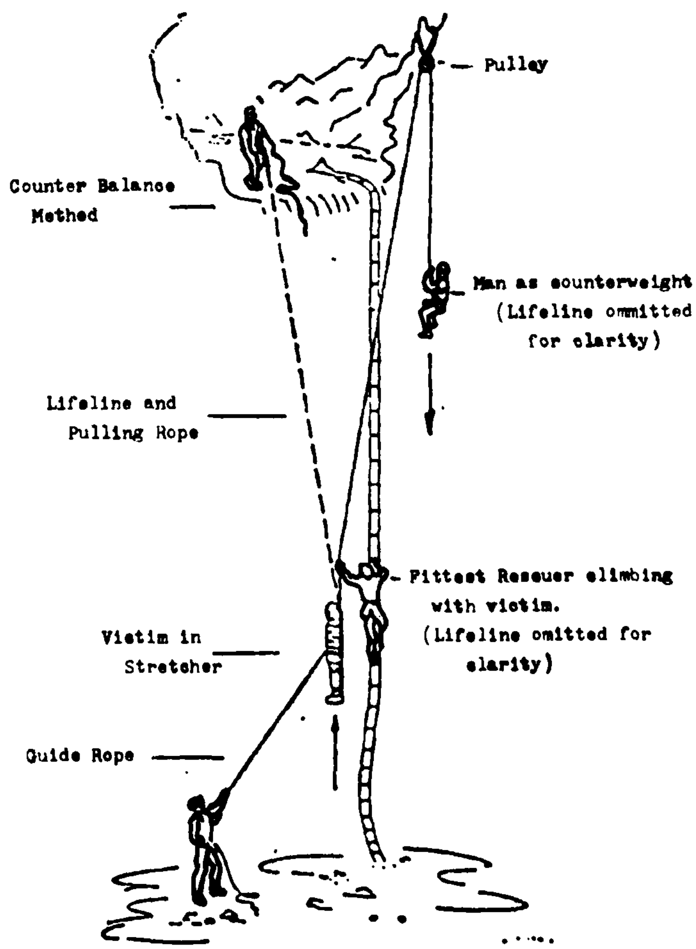


POSITION OF LITTER TENDER OR GUIDE

LIFTING BY COUNTERWEIGHT



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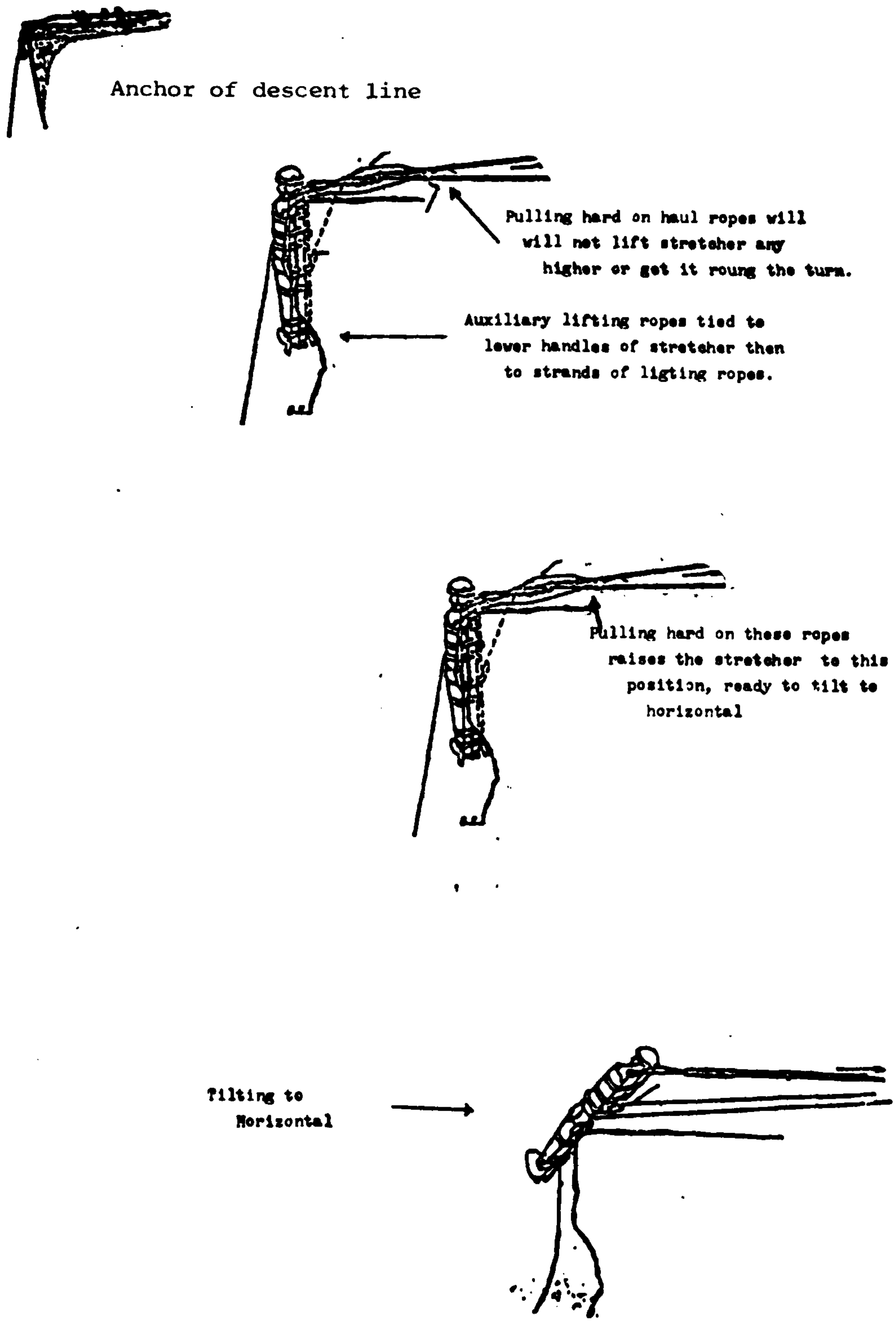

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P A R T F I V E

TRANSPORTATION

TRANSPORTATION ACCIDENTS

Transportation accidents requiring heavy rescue are potentially present in every area of the country. Most rescuers are versed in rescue at the scene of automobile accidents but are not prepared psychologically or otherwise for accidents involving mass transportation conveyances; i.e., buses, trains, planes and ships. The psychological shock of arriving at the scene of an accident involving numerous injured occupants of mass transportation conveyances can and does interfere in the calm, efficient organization of rescuers. The need for preplanning this type of rescue situation cannot be overemphasized. Preplanning means becoming familiar with the construction of those conveyances common to the local area using Disaster Plans and the incident command system and training of personnel in the self-discipline required to maintain their specific task assignment; i.e., abandoning fire suppression equipment to go to the aid of victims, thereby subjecting both victims and rescuers to possible fatal injuries if fire does occur.

Each type of mass transportation conveyance presents specific and specialized problems to the rescuer. An excellent resource to assist rescuers in recognizing and abating these special problems is personnel directly associated with the conveyance involved; i.e., marine incidents - Coast Guard, Navy, Merchant Marine, Local Ship Building and Repair facilities.

Buses

Even though buses are built by different manufacturers, they can be classified as to their principal use, seating arrangement and the type of vehicle suspension. These classifications will be school buses, transit buses, and over-the-road buses.

School buses for K-12 students are constructed using a series of horizontal and vertical beams that are covered inside and out by a metal skin fastened on both sides by rivets or sheet metal screws. The seats are bench type with a removable cushion, secured by legs on the aisle side which are bolted to the floor, and by the frame bolted to a horizontal beam on the opposite side. This type bus does not have an air suspension system.

Transit buses use the same type of beam construction as school buses and have the same type seats, fastened the same way. Transit buses usually have an air suspension system.

Over-the-road buses have a similar type beam construction. The seats are individual and separated by an arm rest. Seats are fastened to the bus by legs, bolted to the floor on the aisle side, a common leg for both seats in the middle of the seat bolted to the floor,

and the frame of the inside seat bolted to a horizontal beam located in the wall of the bus. These buses have an air suspension system to reduce sway and provide a smoother ride on long trips.

A survey of the type of buses in a particular area is important to rescue personnel. In order to perform a safe and efficient rescue operation, rescue personnel must be able to recognize the hazards and problems that may be encountered. For example, the air suspension systems used on certain types of buses can present a hazard to personnel during rescue operations. The buses with air suspension systems actually support the carriage off of the frame by compressed air. If this suspension system fails either from an accident or fire, the carriage of the bus will settle on the frame, leaving only a few inches between the bottom of the bus and the ground. In most cases the buses settle instantly when the air suspension system fails -- there is no warning. If someone has part of their body under the bus or in the engine compartment when the system fails, they could be trapped or injured. When rescue personnel arrive at the scene of an incident involving a bus with an air suspension system and the system has not failed, the bus should be cribbed immediately to prevent it from settling and to create a stable platform for rescue operations.

Some problems which may be common to all accidents involving buses are:

- Limited access
- Narrow aisles and a confined area in which to work
- Lighting, especially for night operations
- Ventilation
- Possibility of a large number of victims with varying degrees of injury
- Possibility of a large fuel spill, either gasoline or diesel

School buses and over-the-road buses usually have one main door and one emergency exit, including windows, while transit buses have two doors. If a bus other than a transit bus has the front damaged, making the main exit unusable, the access points will have to be the emergency exits or the windows. If a bus has rolled on its side, there will be only two entry points which are on ground level -- the front and rear windows. If the bus is on its wheels and the main entry is unusable, the rescue personnel will be operating above ground.

Forcible entry through the side of a bus will require considerable work to cut a usable access. The heaviest beams in bus construction are located at the floor, where the seats bolt to the wall, and above and below the windows. Most seats are located so the passengers can look out of the windows. If the metal skin of the bus is cut away between the beams, under the windows, the seat will be in the way. Even after the seat has been removed, additional cutting will be necessary to cut the heavy beams to make an adequate access point. If the bus is under stress, cutting these main beams can

cause the bus to settle or move. Before any main beams are cut, the bus must be cribbed in position.

The metal skin of a bus is usually fastened by the use of rivets or screws, although some are welded. The fastest way to remove the sheet metal skin of a bus is to cut the heads off the rivets or screws using an air tool with a flat chisel, removing a whole panel at one time. By cutting the rivets or screws (besides being faster than cutting the metal panel), a smooth surface is left over which rescuers can work. Using an air chisel creates an extreme amount of noise inside the bus. Communications by word of mouth is not possible. All of the dirt and dust collected in the cracks will be knocked free. It is important that when the inner metal skin is being cut free someone is inside the bus at the location of the cutting to make sure that victim protection is provided and the cutting will not cause further injury. The victims will have to be prepared for the high noise level and the vibration the cutting will cause.

Using the windows as points of access or egress presents the problems of operating above ground. If the windows are hinged at the top, they will not stay open and will have to be tied open. Some buses have pop-out windows which can be removed. Most school buses have windows that only slide down part way. If the bus is on its wheels, and the normal entry points are not usable, rescue personnel will be working above ground level in a confined area. This means the use of ladders. Communications from the ground to the inside of the bus will also be a problem.

To remove victims from this above ground situation, one of the quickets and easiest methods is to construct an "A" frame using two 24-foot extension ladders. At window level the beams of the "A" frame should be a little over 6 feet apart and secured to the beams between the windows. A pulley or friction brake is connected to the top of the "A" frame. Conenct a line to a stokes litter or basket stretcher. Take the stokes or basket stretcher into the bus through the window and place the victim in it on a blanket. Sliding the stretcher back outside the bus, lower the stretcher to the ground. The victim is removed from the stokes or stretcher on a blanket, and the stokes or stretcher is raised to the window for another victim.

For bus incidents at night, lighting is a critical necessity. Although portable lights are usable, it is better if the lighting can be provided by a light tower outside the bus. The exterior light source is preferable because of the limited amount of room to work inside the bus. Highway departments, fire departments, and any company which is required to work at night may have this type of portable lights.

At the scene of a bus incident requiring rescue operations, there are usually many vehicles in the area with their engines running; i.e., police cars, fire trucks, rescue vehicles, as well as

gasoline generators and power units for tools. When working in the confined area of a bus interior, the exhaust fumes may become a problem both for the victims and rescuers. A fire department smoke ejector or other device to move air may be used to blow the fumes away from the bus or to blow fresh air into the bus.

The narrow aisles in buses create a very limited space in which to work. Some stretchers and spine boards are too wide to fit in the aisle, and must be placed on the top of the seat cushions or across the top of the backs of the seats. Seat removal for additional working space may not be practicable due to victim location. If seat removal is considered, the method of removal must be determined. If the seats are pulled free with a come-a-long or similar tool, the path the seat takes when it breaks free cannot be controlled. If the legs are cut, a short, sharp stub of metal is left. Depending on the circumstances, the best method may be removal of the securing bolts.

A large number of victims presents logistical problems to the rescuers. Organization of the accident scene is important. Trained personnel are needed inside the bus to move the victims properly to the outside. The possibility of two triage areas, one on each side of the bus, should be considered. Usually the closer to the point of impact, the more serious the injuries are and the more difficult it is to get to them.

The presence of a large amount of fuel is always a problem. First, if the fuel is gasoline, the fire hazard is of prime importance and the spill must be foamed. Although diesel fuel is not as flammable as gasoline, it does present a fire hazard and must be controlled. Second, the fuel will make the surface very slippery. Care must be taken in walking, transporting victims and tool use to prevent injury.

To efficiently and effectively handle a major bus incident requires training, coordination and the utilization of resources. To know what your resources are requires preplanning.

<u>Aircraft</u>

Rescue of occupants from damaged aircraft is determinable by several observable conditions upon arrival of rescue personnel.

1. If one or more of the following conditions exist, rescue of occupants is highly <u>unlikely</u>:

    - High impact crash
    - Fire involving aircraft
    - Crash over water
    - Explosion on board

2. Conditions where rescue of occupants is likely:

- Low impact crash
- No fire
- Aircraft is in a location for timely rescue of occupants

All aircraft carry large quantities of fuel, either kerosene, avgas, or a combination of both as in the case of military aircraft. Materials used in construction generally consist of titanium, magnesium, aluminum, and steel alloys. Cargos may involve an assortment of materials such as radioactive, toxic or explosive.

Following is general information about common turbine aircraft now in use. Military aircraft are generally modified versions of commercial models.

Types of Aircraft

There are two types of aircraft with which rescuers should be concerned:

1. Military
   - Fighter
   - Transport

2. Civilian
   - Passenger
   - Cargo

Any of these aircraft may be powered by either turbines (no propellers), turbo-props, or reciprocating. Certainly turbine aircraft represent the largest number flying which may require rescue services.

Military Aircraft - should always be considered as having armament or explosives on board. Except for transport aircraft, military aircraft will contain some type of personnel ejection device. Such devices can be disarmed and/or activated from outside the aircraft by rescuers. Instructions are identified at the point of activation of such devices.

Any military aircraft which is believed to have armament should be approached from the side at a 45-90 degree angle, and NOT from the front or rear in line with the fuselage.

Civilian Aircraft - safety requirements are considerably different than military. However, for the rescuer we will consider them the same except for armament.

Doors and emergency exits are marked with painted dash lines in a contrasting color to the fuselage. However, they may be difficult to see on some aircraft due to painted logos, etc. All regular and emergency exits can be opened from the outside. Care must be taken when opening regular exit doors, since armed devices to deploy

slides, rafts, etc. may activate if not disarmed. Exit opening instructions are posted adjacent to each exit.

Safe and Unsafe Areas of Approach to Aircraft

Do not approach aircraft from inline of engines either front or rear of turbine and from front if propelling. Approach tires/wheels either in line or at a 45 degree angle (heated or burning tire/wheel may blow tire off to side).

Do not approach reciprocating engine aircraft from front or along front of wing line unless you know all engines are stopped.

Access Points

Include regular exits, emergency exits, cockpit windows and possibly cargo doors. If forcible entry through the fuselage is required, it should be done through the top or window areas.

Non-spark producing tools should be used if possible, since there is always the danger of fuel ignition. Foam or other hydrocarbon extinguishing agent should always be used.

Many aircraft have dashed lines on the fuselage designating areas where forcible entry may be accomplished. A discussion with emergency or airport personnel at your local airport will greatly assist your understanding of aircraft construction and emergency entry.

Cargo

Any cargo, transport, or passenger aircraft may be carrying cargos of mixed materials. The materials may be hazardous such as radioactive. Cargo consideration must be exercised during any occupant rescue.

In the event of any aircraft incident, all crash site material must be kept in place and the proper authority notified; i.e., FAA, National Safety Transportation Board, etc.

AIRCRAFT INFORMATION

Listed figures are changeable and may vary between air carriers.

GROSS TAKE OFF WEIGHT	FUSELAGE LENGTH	AIRCRAFT NAME	PASSENGERS (NO CREW)	FUEL GALLONS	NUMBER ENGINES
90,000-114,000	104-125'	DC-9	90-110	3700	2
93,000-108,000	94 - 100'	737	85-100	4000	2
160,000-170,000	133-153'	737	125-150	7000	3
312,000	152'	707	189	21,200	4
273,000	150'	DC-8, 62	179	17,500	4
350,000	188'	DC-8, 63	259	23,000	4
430,000	180'	DC-10	250-330	35,000	4
430,000	178'	L-1011	250-330	32,000	3
670,000	177'	747-SP	266	50,000	4
734,000	231'	747	Up to 490	47,000	4
900,000	245'	C-5 (Mil)	844	49,000	4

All listed aircraft are wet wing.

Commercial air carriers use JP-5, Turbine-A, Jet-A, kerosene-type fuels.

Military use JP-4, Jet-B, a blend of gasoline and kerosene.

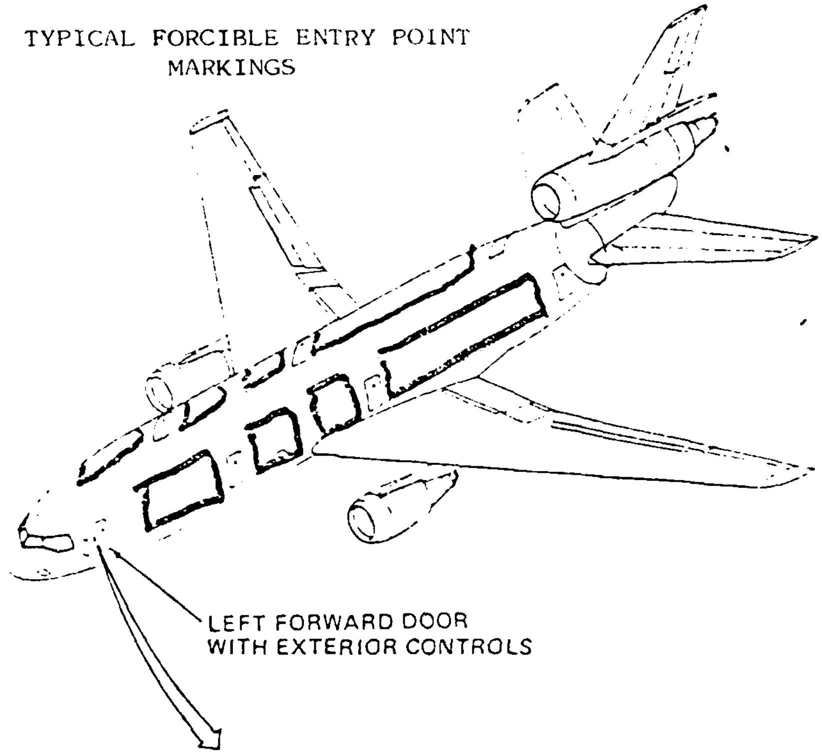
Civilian aircraft use AVGAS with octanes from 100 to 145.

Flame spread:

AVGAS and JP-4 - 700 to 800 FPM
JP-5, kerosene - 100 FPM

Flame spread depends on temperature.

TYPICAL FORCIBLE ENTRY POINT MARKINGS



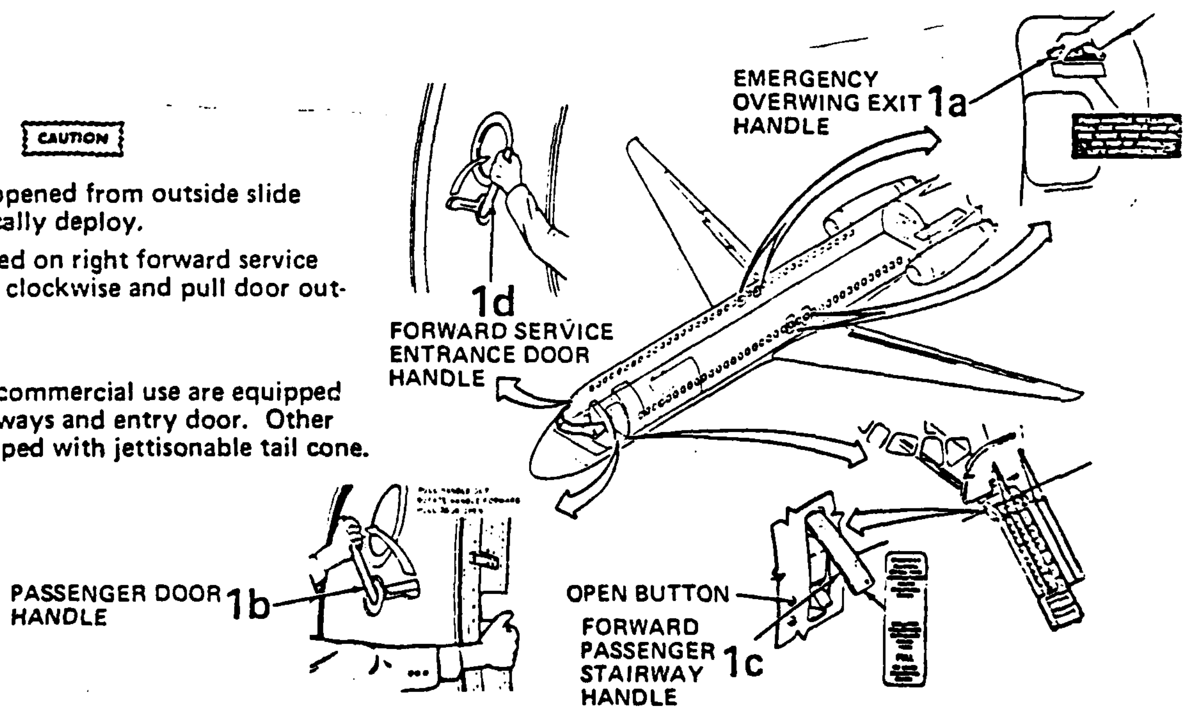
CAUTION

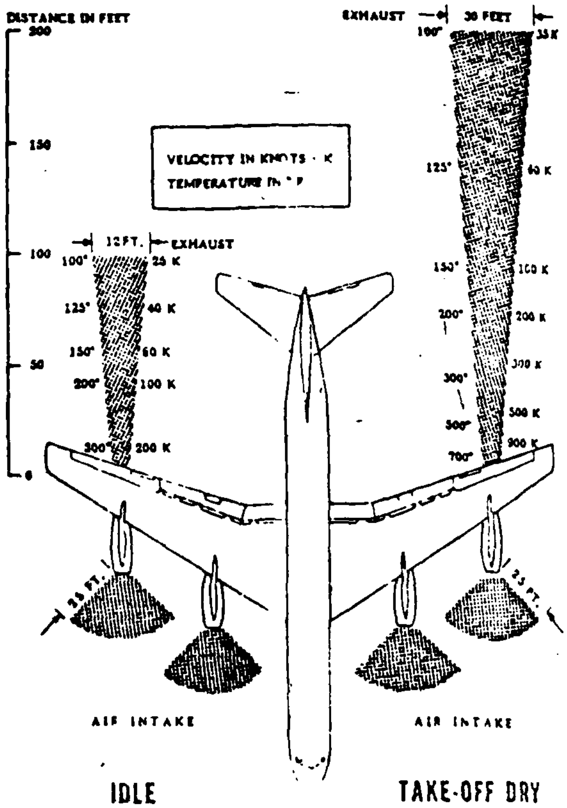
When doors are opened from outside slide chutes automatically deploy.

Pull handle located on right forward service door, out, rotate clockwise and pull door outward.

NOTE:

Some models in commercial use are equipped with rear airstairways and entry door. Other models are equipped with jettisonable tail cone.





Engine intake and exhaust hazard areas of turbine transport aircraft when at idle and take-off power settings.

RAIL TRANSPORTATION EMERGENCIES

Hazards involved with rail transportation can be broken down to two categories -- transportation equipment and hazardous materials being transported.

Equipment

Diesel electric locomotives have two hazards -- the fuel (8,000 gallons or more), and the electrical generation equipment. Fire fighters must always make certain that the electrical generation system is shut down during emergency incidents involving the locomotive to avoid injury from electrical shock. Once this is done, fire fighting operations are the same as for any flammable liquids fire. Rescue operations for trapped crew members can be accomplished either through access doors, windows, or if forced entry is required, the Hurst power tools, pry bars, and other forcible entry equipment may be utilized. The same methods would apply to persons trapped in freight cars or the caboose. When consideration is given to rescue of personnel on freight trains (besides the engine and caboose), remember that railroad crewmen may have been moving in the car area, and also check for transients.

Freight cars vary in size, capacity and construction features depending on the type of material being transported. Many cars are designed specifically for the product they carry such as liquefied petroleum gas, ammonia, chlorine and other substances. Each type car has built-in safety features designed specifically for the product it carries.

Freight cars designed for mechanical refrigeration will have a diesel electric generator on one end of the car and a small fuel tank located beneath the car floor. This tank generally contains not more than 50 gallons.

Cargo which is transported by rail will consist of almost any substance. It may vary from radioactive material to liquefied petroleum gas. All cars with hazardous materials must carry instructional warning as to their most dangerous properties; i.e., flammable, toxic, reactive, etc. In addition, the bill of lading for each is kept in the caboose, should it not be possible to see the warning placards. Cars carrying hazardous materials will usually have the toll-free Chemtrec telephone number prominently displayed to assist rescue personnel.

Incidents involving rail transportation will always bring competent transportation officials on scene. Some transportation companies have contracted with technical experts to handle hazardous material incidents, and each of these agencies has specialized equipment to assist rescue personnel.

Rail transportation companies have access to heavy duty cranes to lift and move their equipment should it be involved in an accident.

UNDERGROUND RAILROADS (Rail Rapid Transit Systems)

The 14th Edition of the NFPA Fire Protection Handbook, Section 17, Chapter 4, discusses these systems. This discussion is limited to the minimum requirements pertaining to ventilation, access/egress, communications, traction power, fire protection, and emergency procedures. However, during actual fire and rescue problems in rapid rail transit system tunnels this information has proven to be inadequate for the training of fire and rescue personnel. This section will discuss the many unique problems encountered by fire and rescue personnel during actual fire and rescue situations in train tunnels.

Communications

Through experience with actual fire and rescue situations it has been learned that four hard line (telephone) communication systems are needed, each placed at intervals in the tunnel as follows:

1. From the tunnel directly to Rapid Transit Central Headquarters.
2. To the Incident Command Post (a pre-arranged site other than fire and Rapid Transit Headquarters).
3. To the fire department dispatch center.
4. For communications within the tunnel.

All systems should be monitored at the Command Post.

In addition to placing these phones at intervals throughout the tunnel, they must be identified in such a manner that rescuers, train crews, or victims can locate them in heavy smoke and poor lighting conditions. All fire/rescue personnel should be trained in the location, marking and use of these telephone systems.

Ventilation

During any fire/rescue situation in a tunnel, ventilation of heat, smoke and fire gases are of prime importance if the rescue is to be successful. Most tunnels have reversible fans for ventilating in either direction, allowing ventilation to be accomplished to benefit the rescue. This system alone will be inadequate if other considerations have not been made.

A rescue or equipment train traveling at its normal speed will cause enough turbulance in the tunnel to overcome and reduce the effects of the ventilation fans. This must be recognized and a slower than normal speed limit set for use during fire/rescue operations.

Doors leading from one train base to another or to a gallery between train bases should be self-closing to minimize smoke travel into clean air areas. All doors leading from train bases to galleries or other bases should be identified in a manner that will allow train crews, rescuers or victims to identify them in heavy smoke and poor lighting conditions. These doors should never be locked.

In addition to the ventilation of the tunnels or train bases, fire fighters and rescuers should be equipped with adequate self-contained breathing apparatus. The traditional 30-minute duration breathing apparatus used in the fire service may prove to be inadequate for fire/rescue operations. Fire/rescue personnel assigned to the tunnels of the Bay Area Rapid Transit System in Oakland/San Francisco Bay Area have 4-hour breathing apparatus available. These units present some unique problems to the rescuer. The maximum work time during fire/rescue operations is only one to two hours with two to three hours reserve time. The Oakland, California Fire Department has a policy that these 4 hour breathing apparatus are actually 30-minute breathing apparatus with a 3½-hour reserve air supply.

Training Requirements

All fire and rescue personnel should be totally familiar with and sub-surface rail system in their jurisdiction. Fire and rescue personnel should have input with the policies of the transit authority concerning the operations of any sub-surface rail system. A stringent inspection program of ventilation and communication systems and ingress/egress routes should be developed and carried out by both fire, rescue, and transit system authorities.

Simulated fire and rescue operations for these types of facilities should be held annually in order to develop and maintain the coordination, identify system deficiencies, and expose all personnel to the problems and limitations in a controlled non-emergency situation.

MARINE

Rescue of occupants (crew or passengers) from damaged vessels requires special knowledge, equipment, and techniques. Vessels may vary in size to over 1,000 feet long. If a passenger vessel, there could easily be 1,000 passengers and crew on board.

If a vessel is involved in an incident while at sea, local fire/rescue resources will not be involved. However, if the incident occures in a horbor, river or inland waterway, such local resources may very well be involved in rescue operations.

Types of Vessels

Vessels will be either military or commercial. There is very little difference in construction except for war ships. This manual will address commercial vessels which include:

- Tankers
- Cargo vessels
- Passenger vessels

Other vessels such as barges, tugs, ferries, container, auto, and bulk carriers present special problems and will not be discussed.

Construction Materials

Generally, heavy steel plate and beams are used to construct the frame, hull covering and decking. These steel plates may be $1\frac{1}{2}$ inches thick. Other materials such as wood, fiberglass, reinforced plastic, aluminum and concrete may be used to finish the vessel.

Vessels may be more than 150 feet in height from the keel to the top of the superstructure, and have 10 or more decks. In a sense, this represents a floating high-rise building encased in thick steel.

Construction Features

Cargo Vessels - generally have four to ten holds which may run from the bottom of the vessel to the main deck. These holds can be divided by planking material or steel bulkheads.

The engine and/or boiler rooms are generally located in the middle of the vessel (midship). Cargo holds are numbered starting at the bow (stem) and increase numerically toward the stern. Hoisting equipment may be attached to the vessel for cargo loading and unloading.

Passenger Vessels - Consist of 4 to 6 decks below the main deck and as many above. Decks may be numbered or lettered.

Tank Vessels - Carry liquid cargos that range from molasses to liquefied natural gas. In older vessels, the engine and/or boiler room will be in the middle of the ship; however, in newer tankers (including super-tankers), the engine and/or boiler room is in the stern.

Access for Rescue

On any vessel, access for rescue is extremely difficult and very limited. Long, narrow passageways, stairs, lack of lighting, damaged areas, and hazardous atmospheres make any attempted rescue tedious and dangerous.

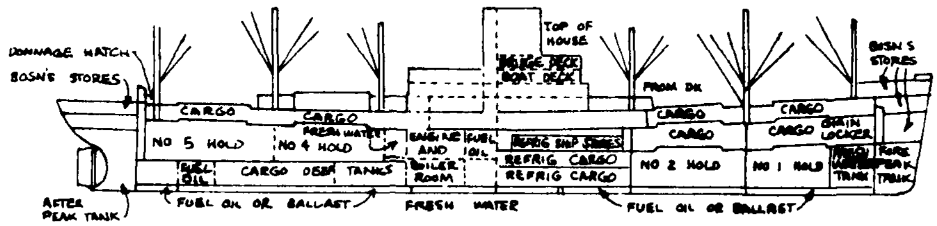
Resources

During any attempted shipboard rescue, marine personnel knowledgeable in this area must be contacted for assistance. Their help is invaluable, and any large-scale rescue cannot be successful without such assistance.

Conclusion

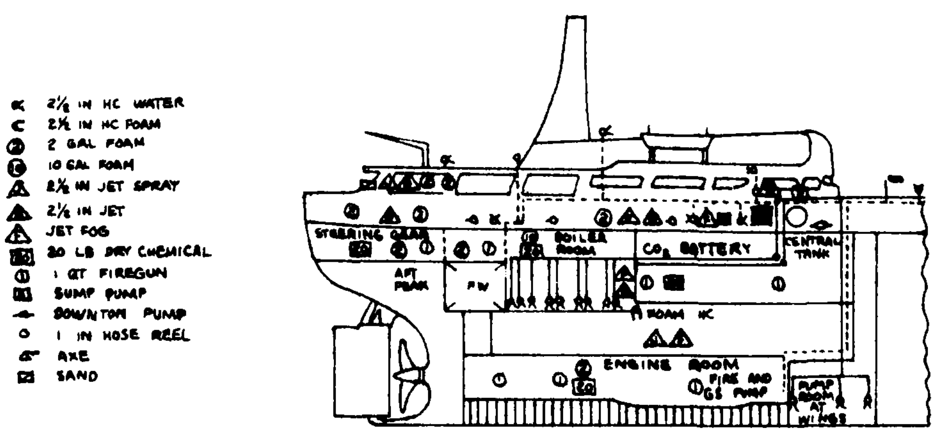
Shipboard rescues require special knowledge and resources. Without such resources and assistance, rescue operations will most likely be unsuccessful, and may in fact, victimize the rescuer himself.

<u>MARINE</u>



CARGO PASSENGER VESSEL SHOWING LOCATION OF THE PRINCIPAL CARGO AND TANK SPACES.

FIRE FIGHTING PLAN FOR THE AFT END OF A SUPER TANKER.



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